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Animal Husbandry: The Period 1973-1995

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Phil. Trans. R. Soc. Lond. B 1985 **310**, 275-288
doi: 10.1098/rstb.1985.0116

Phil. Trans. R. Soc. Lond. B **310**, 275–288 (1985)
Printed in Great Britain

Animal husbandry: the period 1973–1995

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In the last decade the intensification of the pig and poultry industries has continued with increases in production unit size and in efficiency. This has come about as a response to rising costs, competition and reasonable end-product prices. The dairy industry has also expanded output through increasing milk yield per cow, encouraged by favourable market support. However, efficiency of feed conversion to milk production is still not directly selected for in dairy cattle. Developments in beef cattle have been away from intensive systems of production in an effort to reduce capital expenditure and increases in sheep productivity have been largely through increased stocking rates, greater fertilizer use and better grazing systems. In the next decade there are many feasible technological advances awaiting application. The use of computer simulation is likely to assist in predicting quantitative and qualitative body compositional responses to nutrition and in increasing the efficiency of grass utilization, while microprocessor technology will be developed into artificial aids to the stockman. Studies of reproductive physiology will continue to help increase output, especially with pigs and sheep. The building of sophisticated housing is likely to be justified for pigs, poultry, dairy cattle and calves, but not for suckler beef and sheep. There is likely to be greater use of centralized breeding schemes for dairy cattle, beef cattle and sheep. The future application of technology will be limited by a number of socio-economic factors. For example, the use of milk quotas to control surplus production will act as a powerful economic constraint to increased milk production and the growing public concern over animal welfare, pollution and health aspects of animal produce will exert increasing pressure on certain systems of production.

Introduction

The past two decades have seen major changes in the structure of animal production in Europe. Wilson (1973) previously reviewed the first period of change (1960–73). This paper will examine the period, 1973–95. The effect of entry to the European Community (E.C.) will be discussed and the major limitations to future developments will be outlined. Previously the limits to development in animal production have been largely biological; in the next decade, socio-economic pressures will exert a greater influence.

The period 1973–84

The entry of the U.K. into the European Community (E.C.) in 1973 brought about significant changes in the method by which British farmers received payment for their produce. The former 'deficiency payments system' was replaced by an intervention system operated through the Common Agricultural Policy (C.A.P.) with a greater emphasis on ensuring that producers receive a reasonable return from their enterprises.

Poultry and pigs

The intensification of the poultry and pig industries, already well established in 1973, has continued. The C.A.P. has had little effect on this as it provides only a lightly structured support mechanism for these sectors (Harris *et al.* 1983). The continuing intensification of the management of these species has been in response to the market pressures of rising costs, principally of labour and energy, and of competition resulting in decreasing returns per animal. Many less efficient producers have been unable to compete and the mean size of units has steadily increased as the more efficient farmers have expanded. Control of the environment, with beneficial effects on production, has been achieved by sophisticated housing and equipment. Lighting régimes have enabled the poultry producer to increase egg production and control pullet maturation (Nesheim *et al.* 1979). Temperature and humidity control has resulted in enhanced feed conversion efficiency (Webster 1983).

The genetic improvement of poultry and pigs is now controlled by a small number of breeding companies in contrast to the breed societies that still dominate the ruminant industries. Considerable progress has been made in the potential for egg production (see table 1), growth rate and feed efficiency of broilers (see table 2) and the feed conversion ratio and lean carcass content of pigs (see table 3). Improvements in feed conversion efficiency are essential to profitability as feed represents a high proportion of the total production costs in most livestock enterprises (Spedding *et al.* 1981).

Table 1. Recent actual and estimated future annual egg yields for laying poultry (September to August)

(After *Poultry World* 1982.)

system of management	1974	1975	1976	1977	1978	1979	1980	2000
free range	173	176	188	192	185	197	197	232[a]
deep litter and others	201	207	217	225	219	228	230	272[a]
battery	232	236	239	245	246	249	252	288[a]

[a] Estimated by authors.

Table 2. Recent actual and estimated future feed conversion and growth rate for broilers

(After Van Den Eynden 1978.)

	1960	1970	1978	1990	2000
feed conversion ratio (kg feed:kg gain)	2.10	1.92	1.79	1.64	1.58
daily gain/g	20	33	40	51	56

The improvement in the genetic potential for growth, feed conversion and egg production has been exploited by improvements in animal nutrition, such as the increased use of high nutrient density diets, mostly fed as compound feed.

Although many technological improvements which could further increase the competitiveness of these industries are feasible, the greatest limitation to continuing development of intensive farming systems will be socio-economic constraints, such as pollution and animal welfare.

Table 3. Estimates of annual genetic change in pigs in the U.K.

(After Aumaitre *et al.* 1982; Mitchell *et al.* 1982.)

selection objective	estimated annual genetic improvement	monetary value per pig per year/pence	percentage of total improvement
feed conversion ratio (kg:kg)	0.027	23.2	31
daily gain/g	5	3.4	5
eye muscle area/cm^2	0.27	0.8	1
killing-out (percentage)	0.11	6.9	9
trimming (percentage)	0.08	4.4	6
lean in side (percentage)	0.68	37.6	49
total	—	76.0	100

Dairy cows

Unlike poultry and pig production enterprises, which involve a relatively small number of specialized units, over 50% of E.C. farmers (the U.K. and Italy being important exceptions) own dairy cows and for many it is the main enterprise (Harris *et al.* 1983). The importance of dairying in the E.C. context has resulted in favourable market support for milk. This market support has encouraged an increase in the size of dairy herds in the U.K. and an increase in milk yield per cow throughout the E.C. (Milk Marketing Board 1980, 1981, 1982, 1983) (see tables 4 and 5). About half of the increase in yields is estimated to be a result of achievements in breeding, and half to improvements in feeding and management (United Nations Economic Commission for Europe 1983).

Table 4. Recent actual and estimated future milk yields in E.C. countries, 1960–2000

(After Milk Marketing Board 1983; Allen *et al.* 1982.)

factor	1960	1970	1975	1982	2000
milk yield per cow per annum[a]/kg	2925	3584	3802	4433	4827

[a] Mean data from Belgium and Luxembourg, Denmark, France, Germany, Ireland, The Netherlands, United Kingdom.

Table 5. Recent actual and estimated future mean size of dairy herds in four E.C. countries, 1970–2000

(After Milk Marketing Board 1981; 1982.)

	1970	1975	1980	2000
Germany	7	9	12	22[a]
France	9	12	14	24[a]
The Netherlands	16	24	35	48[a]
United Kingdom	31	40	51	66[a]

[a] Estimated by authors.

Genetic potential has been increased by substitution for the indigenous breeds, such as the Shorthorn and Ayrshire, by the Friesian–Holstein. Progeny testing schemes have accelerated the process of genetic improvement within breeds. As in pigs and poultry, this increased genetic potential has been exploited by the greater use of cereals and oilcakes given in the form of compound feeds (Allen *et al.* 1982). A greater precision in rationing of the dairy cow (and other ruminants) has resulted from the replacement of the starch equivalent (s.e.) energy system by the metabolizable energy (m.e.) system (MAFF 1975) and by the recent introduction of the new protein system that takes into account both the N requirements of the rumen micro-organisms as well as those of the animal's tissues (Agricultural Research Council 1980).

The increase in herd size has resulted in greater sophistication of milking parlours and dairy cow housing. Cubicles have progressively replaced loose housing and cow-shed systems (Haines 1982) and in the U.K. the capital costs have been partly funded by generous grants.

The introduction of a new payment scheme by the Milk Marketing Board in April 1984 has increased the attention given to the yield of individual milk solids rather than total quantity. Selection for increased efficiency of solids production would be an effective long-term strategy (Wilson & Lawrence 1984) while in the shorter term feed manipulation can have significant effects (Rook & Thomas 1980). The need for greater control over milk quality may increase the use of protected fats and proteins in dairy diets (Thomas 1980).

The new E.C. quota system represents a major limitation to the future development of the dairy industry. Although unit costs are lowest in herds containing in excess of 100 cows (Haines 1982), quotas will reduce increases in the size of the larger E.C. dairy herds in the immediate future (see table 5). Farmers should respond by increasing the efficiency of their existing enterprises rather than by expanding them, and progeny testing schemes that do not measure the efficiency of feed conversion to milk solids will need to be replaced by more relevant breeding programmes.

Beef cattle

Beef production in the U.K. is a by-product of the dairy industry with production levels largely dependent on changes in numbers of dairy cows. Because of their low inherent biological efficiency, beef and sheepmeat have suffered from competition from other meats, notably pig and poultry meats, and this has resulted in a static demand for and a growing E.C. surplus of beef (Harris *et al.* 1983).

Unlike the feed-lot systems of North America, beef production in the U.K. is still located mainly in the upland (marginal) areas or on lowland farms as part of a mixed farming system. Intensive systems, such as barley–beef, have been replaced by semi-intensive 18-month grass–cereal beef. The rate of gain during the grass finishing period of grass–cereal beef has been increased by the use of hormonal growth-promoting implants (Allen & Kilkenny 1984). Although the output of intensively farmed bull-beef continues to increase, it represents only a small proportion of total U.K. beef production.

To offset rising feed costs more by-products, such as nutritionally improved straw, have been used in beef diets (Cuthbert *et al.* 1978). Furthermore, recent research has emphasized that suckler cows and calves can be out-wintered in low-cost housing without prejudicing the future growth of the calves (Broadbent *et al.* 1983) (see table 6).

As in the dairy industry, breed substitution has occurred, with an increase in the use of continental bulls (for example, Charolais, Limousin and Simmental) on Friesian dairy cows or as terminal sires on suckler cows. These imported bulls are heavier than indigenous U.K. breeds, with a consequent requirement either to slaughter their progeny at heavier masses or to feed them more intensively to achieve equal fatness. They are leaner at slaughter at a fixed mass resulting in improved meat quality. This is important because the consumer now discriminates against excess animal fat. The challenge for the beef producer is to reduce the competitive edge that the pig and poultry industries have established in the last two decades.

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Table 6. Effect of shelter on the performance of autumn calving beef cows and their cows[a]

(After Broadbent *et al.* 1983.)

	slatted house	topless slatted pen	sheltered paddock	exposed paddock
cow mass change/kg				
loss over winter	1	25	35	26
gain during summer excluding conceptus	12	35	40	35
calf live mass/kg				
at turnout (weaning)	264	248	240	241
at housing (yearling)	342	334	339	336

[a] Data: unadjusted means for 5 years (1977–82).

Sheep

There was no E.C. sheep régime until October 1980 and therefore changes in sheep production have been less marked than in other sectors (Harris *et al.* 1983). Since 1980 profits have risen sharply while the decline in the consumption of sheep meat has continued (Chamberlain & Howe 1983).

One limitation to increasing the productivity of sheep production is that sheep are subject to seasonal variation in growth and reproduction, normally lambing only once a year. Certain features of their physiology, such as growth and feed intake, are subject to the effect of changing day length (Forbes 1982). Attempts to produce more than one lamb crop a year from non-seasonal breeds, such as the Dorset Horn, have met with only limited success (Flamant *et al.* 1982). In contrast to pigs, there has been no significant improvement in prolificacy and thus increases in gross margins per ewe and per hectare have mainly resulted from increased stocking rates and a greater use of fertilizer nitrogen (Kilkenny 1983). The use of more fecund breeds, such as the Australian Baroola, may increase prolificacy in future.

Fifty-seven per cent of breeding ewes in the U.K. are found on upland or hill farms where technical improvement is limited by the harsh environment. The two-pasture system (Russel 1983), which sets aside improved grassland for the critical periods of lactation and mating, and the use of feedblocks to supplement hill ewes during mid to late gestation, have helped to improve the output of lambs from hill farms. The use of housing for in-wintering ewes is limited by the capital cost that is often not recouped by an increase in profits (Speedy 1980).

The period 1984–95: the technological environment

Future agriculture will require more, not less, technology. The way to overcome new problems, including those caused by existing technologies, is by more research and development. There is not sufficient available knowledge of relevance to British conditions to allow U.K. agriculture to improve its competitive position in the E.C. A recent report suggests that the efficiency of U.K. agriculture is in danger of falling behind that of other E.C. countries (Centre for Agricultural Strategy 1980). Research and development and the application of appropriate technology by effective extension work must play an important role in rectifying this imbalance. The lead-time available for implementing research and development findings are short but are still important and U.K. farmers must translate successful research and development work into practice in a shorter period than their competitors.

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Feeds and feeding methods

Forecasts suggest that E.C. countries will not face future shortages of concentrated feedstuffs, but a major problem to the livestock sector will be the price at which feed grains and other commodities can be bought (Van Dijk *et al.* 1982). Continuing use will be made of the so-called 'cereal substitutes' such as cassava, citrus pulp and maize gluten. In addition, livestock production will come to rely more heavily on diets based on by-products such as animal excreta and vegetable wastes (Wilson & Brigstocke 1977). As the E.C. is at present almost wholly dependent on the Americas for its soybean-based protein supply, alternative protein sources will be increasingly employed. Temperate legumes provide a potential source of home-grown protein for inclusion in pig diets. Peas require no heat treatment before inclusion in rations and provide useful on-farm protein supplies (Perez 1980). The use of rapeseed and lupin meal should increase as varieties low in growth and intake inhibitors are produced (Aumaitre *et al.* 1982).

In cattle, the extent to which bought-in feeds are used to supplement forage crops will continue to depend partly on the nutritional quality of the forages and their intake by cattle and partly on the relation of milk and beef prices to concentrate price. There is likely to be a decline in the use of lead- and step-feeding in dairy cattle and an increase in the use of flat-rate feeding methods. Recent research has shown that, provided moderate yielding cows are given *ad libitum* access to good-quality silage, the system of concentrate allocation strictly according to yield is unnecessary (Gordon 1984) (see table 7). In suckler herds emphasis will be placed on the attainment of target condition scores by optimizing the use of cheap forage and by using the cows' body reserves to buffer against adverse changes in their nutritional régime (Lowman *et al.* 1984).

The cost of feed will necessitate improvements in the efficiency with which it is rationed. Computer modelling of responses to inputs will assist in optimizing the levels of protein and energy in livestock diets (Whittemore 1983). The Edinburgh Pig Model, already in national demand, produces predictions of pig live mass change and carcass grade, using biochemical and physiological information to estimate lipid and protein gains from stated feed inputs

Table 7. The effect of pattern of concentrate allocation on performance of autumn-calving cows

(After Gordon 1984.)

	concentrate allocation and animal performance		
	flat-rate feeding system	step feeding system	significance of main effects
feed intake			
concentrate intake of cows/t	1.07	1.05	n.s.
silage d.m. intake/(kg d^{-1})	9.95	9.50	n.s.
milk output/kg			
total winter yield	3728	3725	n.s.
total summer yield	1874	1820	n.s.
milk composition/(g kg^{-1})			
lactation butterfat	38.9	38.6	n.s.
lactation protein	32.1	31.5	n.s.
reproductive performance			
calving index/d	373	369	n.s.

(Whittemore 1981). This approach encourages the use of the nutrient specifications for diets and feed allowances as variables in a management scheme that aims to optimize the nutritional value and cost of a diet and the rate and type of growth achieved (Aumaitre *et al.* 1982).

Pasture utilization

The efficient use of forage has a large effect on the profitability of ruminant enterprises, as a result of its relatively low cost as an energy and protein source. The use of utilized metabolizable energy (u.m.e.) as a check on the efficiency of grass utilization has illustrated that many farms are making insufficient use of grass (Walsh 1982). High u.m.es are achieved by balancing individual animal output with stocking rate. The buffer grazing system (Illius & Lowman 1983), in which a proportion of the grazing area is reserved as a buffer either to be conserved or grazed if grass is in short supply, has been found to make more efficient use of grass during the period of maximum production. Storage feeding, which entails housing animals throughout the year and feeding them conserved grass, entails extra capital cost and requires further economic assessment (Doyle & Wilkins 1983).

As in rationing concentrate feeds, simulation models can be applied to optimize stocking rates for maximum production. Wright & Pringle (1983) describe a simple model to derive stocking rates that maximize milk fat and profit per hectare.

Growth promotion

A novel approach to growth promotion by auto-immunization of sheep or steers against their own somatostatin may prove a useful alternative to hormonal growth promoters in current use. In a recent experiment, auto-immunized three-week-old lambs grew to slaughter mass in 13.5 weeks as opposed to 17 weeks for controls, with some improvement in feed conversion efficiency and no increase in the deposition of fat (Spencer *et al.* 1983) (see table 8). Although past experiments have been conducted on intensively kept animals, future trials may indicate the usefulness of this technique in increasing the efficiency of grazing livestock without risk of tissue residues.

Table 8. Lamb mass gains, feed intakes and feed utilization in controls and in somatostatin immunized lambs

(After Spencer *et al.* 1983.)

	control to slaughter	treated to slaughter	treated to 30 kg
time/d	119	119	94.5
mass gain/kg	24.3	29.6	24.6
mean daily feed intake per kilogram livemass/g			
pellets	31.0	27.4	25.1
hay	5.7	5.7	5.2
total energy intake per lamb/GJ	1.38	1.47	1.02
feed conversion ratio/(kg:kg)	56.8	49.7	41.4

Reproduction

The breeding populations on which animal production systems are based affect the overall efficiency of the system by adding to the quantity of food required, but add little to the output of the end-product (Spedding *et al.* 1981). The effects of increasing the number of surviving progeny on the efficiency of production have been calculated for different species (Large 1976).

In pigs the large output per breeding sow has a marked effect on efficiency when compared with the small output achieved per breeding ewe.

In the dairy cow the use of modelling has illustrated the importance of calving interval on physical and economic performance (James & Esslemont 1979). Increasing the efficiency of oestrous detection in dairy cows should receive greater attention. The next decade should see the use of microchip technology to record the temperature and progesterone levels of milk as an aid to oestrous detection and pregnancy diagnosis. Apart from increasing accuracy of measurement, such systems would also enable reductions to be made in labour costs and in chronic diseases such as mastitis.

Besides the advantages of genetic improvement programmes, the technologies of multiple ovulation and embryo transfer have potential for increasing the productivity of beef enterprises through the implantation of twin embryos in recipient cows (Wilson 1973). However, until the costs of embryo transplantation are substantially reduced, the procedure will find little commercial application other than in genetic selection programmes (Wilmut & Hume 1978). There are disadvantages associated with the induction of twinning in cattle, including a high incidence of retained placentae, increases in the occurrence of freemartins and an increased incidence of cystic ovaries (Bearden & Fuquay 1984).

Predetermination of the sex of a calf would have major genetic and production consequences (Allen *et al.* 1982). Previous research has not produced a practical methodology but the application of a y-chromosomal staining technique developed with human semen offers some hope for the future (Bearden & Fuquay 1984).

Research into the control of the oestrous cycle in sheep has revealed that light-induced alteration in prolactin levels involves the pineal gland and the production of melatonin (Kennaway *et al.* 1982*a*). Melatonin implants have been shown to mirror the effect of changing day length (Kennaway *et al.* 1982*b*). Development of this technique may offer a more practicable method for controlling the seasonality of breeding in sheep than previous systems, which relied on light-controlled intensive housing.

In future greater attention needs to be given to the overall breeding lifetime of the female. In particular, a greater understanding of factors affecting the reproductive physiology and behaviour of primiparous dams is required. Although ewe-lambs and ewes have equally favourable uterine environments and each have similar endocrine responses to oestrous synchronization treatment, ewe-lambs experience a higher prenatal mortality for reasons which are unclear (Quirke 1981). In pigs, gilts are more likely to be prepuberal or behaviourally anoestrous if confined during their development, or reared during the summer rather than the winter (Christenson 1981). Gilts have also been found harder to rebreed during the summer than the winter. Recent work has shown that the addition of supplemental fatty acids to the diet reduced the weaning to oestrous period in summer to approximately the same length as that found in winter (Cox *et al.* 1983).

Housing, mechanization and animal health

U.K. agriculture has invested a greater amount of capital in machinery and buildings and uses more labour and other resources to produce a given output compared with certain other E.C. countries (Centre for Agricultural Strategy 1980). In view of this, livestock producers should only invest in equipment and buildings where the cost is clearly justified.

Attempts to cut labour costs in pig, poultry and milk production will continue by the introduction of computerization. One promising area is the use of microprocessor-based equipment for the automatic monitoring of animals. Such systems can automatically collect acceptable records of body-mass trends in dairy cows and broiler chickens (Turner 1981).

One of the most costly consequences of the use of intensive housing systems is that when they are not efficiently managed and controlled there has been an increased incidence of multifactorial diseases, caused by a combination of pathogenic and environmental factors (Ludvigsen *et al.* 1982). In dairy cattle, infections such as foot-rot and mastitis result in production losses of up to 15% of the value of the end product (Yubero 1981). A Yugoslavian system for pigs, the Lego-system, reduces disease by housing all stages of production under one roof (United Nations Economic Commission for Europe 1983). Orthoxenic production units are proposed to solve problems of disease in poultry production by housing the birds in closed units that are only reached through airlocks and by filtering incoming air. At present such systems would be justified for parent stock, as the additional cost would be insignificant compared with the total expense of selection, research and conventional disease treatment. Their use for the other stages of production requires further economic assessment (United Nations Economic Commission for Europe 1983).

Genetic improvement

Over the past 20 years selective breeding for production traits has resulted in substantial improvement in genetic potential for efficient broiler and pig growth, greater egg production and higher milk yield per cow. Similar improvements are required in other areas, such as efficiency of milk solids production and efficient growth in beef cattle and sheep. The future should see a greater use of centralized breeding schemes for ruminants in the U.K., similar to those used in the pig and poultry industries.

During the next 10 years genetic engineering may be applied to certain aspects of livestock production. It is difficult to predict a timetable of development of this new field because it is an expensive new technology and costs must be related to potential benefits.

The period 1984–95: the socio-economic environment

The future development of animal production systems will be more influenced than in the past by non-biological limitations. Of increasing importance will be the views held by the urbanized populations of the E.C. (see table 9), and the consequences of the political expression of those views.

Table 9. Recent actual and future estimated trends in the agricultural labour force of four E.C. countries, 1960–2000 (percentage of total labour)

(After Milk Marketing Board 1981; 1983.)

	1960	1965	1970	1975	1980	2000
Italy	31.5	25.1	18.8	15.1	13.1	8.2[a]
France	22.1	17.6	13.9	10.3	9.6	5.8[a]
Germany	13.7	10.7	8.5	7.2	5.2	3.0[a]
United Kingdom	3.8	3.2	2.8	2.6	2.7	2.5[a]

[a] Estimated by authors.

The Common Agricultural Policy

Forecasts, up to the year 2000, suggest that the population of E.C. countries will approach zero growth and that the supply of certain animal products, in particular milk, eggs, poultry meat and beef, will outstrip demand (United Nations Economic Commission for Europe 1983). The existence of food surpluses will necessitate radical reform of the C.A.P. While most economists favour a part return to a non-protectionist market (Adam Smith Institute 1983; Tangerman 1984), the large effect of such a change on the farming sector has meant that some protection is recognized as being politically desirable if not essential (Coleman 1983).

The imposition of milk quotas represents a further move away from a free market situation and must therefore be an incomplete solution to the problems of milk surpluses, particularly because it protects inefficient producers and maintains high prices (Tangerman 1984). Society will be increasingly reluctant to pay high prices for food caused by artificial restrictions on the market or inefficiencies in the industry.

Animal production and public health

In recent years there has been a growing concern over the effects of animal products on the health of consumers. Particular attention has focused on the theoretical link between levels of dietary fat, cholesterol and coronary heart disease (c.h.d.). The recent campaign against saturated animal fats has led to the decline in the demand for whole milk and an increased consumption of low-fat milks.

Whilst the public in general may accept a causal relation between the intake of dietary fat and c.h.d., medical opinion remains divided. Epidemiological studies (Stamler 1982) found evidence of increased c.h.d. levels in populations that consumed high levels of dietary fat. However, it is recognized that considerable variation in the incidence of c.h.d. exists between countries with approximately similar levels of dietary fat and other factors, such as exercise, sugar intake and cigarette smoking, are also involved (Armstrong *et al.* 1975).

Reiser (1978) has suggested that most of the population have non-pathological levels of serum cholesterol while a small proportion have pathological ones, as a result of their intake of dietary fat. There is a danger in advising the total population on safe levels of dietary fat on the basis of a mixed sample containing both these disparate groups. The role of genetic factors in determining the susceptibility of subjects to c.h.d. requires further study (Neufield & Goldbourt 1983).

There is also concern that harmful residues may be present in meat following the use of certain hormonal growth promoters. These fears appear unfounded when implanted promoters are used in accordance with the relevant product licence, because in these cases the tissue residues will not exceed safe maximum levels. Moreover, silastic implants have now been designed which further reduce tissue residues (Allen *et al.* 1982). However, growth-promoting implants are banned in some E.C. countries and have not been licensed for use in others, and the long-term future use of such products in the U.K. cannot be guaranteed.

These are two examples of how public concern over health can directly affect the consumption of, or the regulations pertaining to, animal products. Farming organizations must ensure that the products they sell are as safe and wholesome as possible, that the constraints on the use of additives are vigorously observed and that the public are professionally reassured on these health issues.

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Animal welfare

The debate on animal welfare is complex because much of the argument is based on aspects of moral philosophy rather than science. As Dawkins (1980) points out, this can lead to different people concerned with animal welfare having quite separate aims. Some may want to see the abolition of all livestock farming that results in 'suffering' and 'untimely death', while others wish to ensure that animals are husbanded and killed in as humane a way as possible.

Recent concern is directed at the practices involved in the intensive housing of poultry and pigs. Free-choice experiments have yielded contradictory results (Dawkins 1977) and attempts to find physiological correlations with stress and suffering have been frustrated by the complexity of factors that give rise to different behavioural states.

In the case of tethered sows, recent research has indicated that this form of confinement may be stressful to the pig and cause abnormal behaviour such as bar-biting. Cronin *et al.* (1984) found that injection with an endogenous opioid blocking drug (Naloxone) dramatically reduced the occurrence of stereotypic bar-biting behaviour. This finding suggests that pigs produce endogenous opioids through performing the seemingly irrelevant stereotypic behaviour and that the opiod enables the pig to 'cope' with its restricted environment. This work indicates that the sow is adversely affected by restrictive tethering, as found in traditional intensive housing systems.

Perhaps more difficult than the scientific investigation of complex animal welfare issues is the implementation of legislation to 'ensure' high standards of welfare and to prevent animal 'suffering'. Such laws, if meticulously enforced, could have profound effects on the availability and price of food. It seems inevitable that legislation must be a compromise and tend towards the pragmatic, otherwise its effectiveness will be reduced. At the end of the day it is good stockmanship and animal husbandry which are the essential factors in ensuring the humane treatment of farm livestock.

Pollution

The intensive housing of pigs and poultry has led to problems in the disposal of manure and concern over environmental pollution. A variety of options are available for the treatment of farm wastes, but recycling by spreading the manure over large areas still appears to be the most practical solution. The major problem is the provision of sufficient arable land close to intensive animal units to ensure correct application rates. In several countries laws have been enacted to protect the environment and in some of these a licence is necessary to open or extend an intensive animal enterprise.

Future options

The socio-economic factors mentioned above, further complicated by concern over the use of fossil fuels in agriculture (Wilson & Brigstocke 1980), have led to an increased interest in alternative systems of production, especially lower input:lower output systems. Possible future legislation limiting the size of intensive units may further encourage a growth of less intensive systems. The search for alternative systems may be enhanced by a concern for welfare or pollution, but all systems must be economically viable to encourage their adoption by producers. A comparison of semi-intensive and intensive pig systems by Carnell (1983) showed that the difference in productivity was less marked than is usually supposed (see table 10).

Table 10. Simulated financial performance of pig breeding herds under different management systems

(After Carnell 1983.)

	management system		
	intensive	semi-intensive	extensive
physical description			
weaning age/d	21	21	49
farrowing environment	crates	crates	outdoor
dry sow environment	tethers	yards	outdoor
rearing environment	flat-deck	verandah	verandah
financial performance/£			
average feed cost/t	158	159	153
cost per weaner to 56 days			
feed	12.98	13.18	14.88
labour	2.58	2.84	2.89
capital	3.23	3.06	1.13
other costs	3.55	3.55	4.08
total cost	22.34	22.68	22.98
cost per kilogram of pig reared	1.21	1.22	1.21

Spedding (1984) suggests that lower input systems could prove a viable alternative to intensive systems. It is clear that further research is required, and computer simulation studies of future trends in energy and feed costs relative to end-product value will prove useful.

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