PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Animal Health [and Discussion]

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Animal health

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The problems of animal health in the Britain of the 1980s must be visualized in terms of increased intensivism, larger units, and a further diminished labour force. This will demand the increased application of professional services and more highly skilled planning in unit economics, disease control, nutrition, genetics, and in a pasture management integrated with extensive animal production systems.

Steadily increasing production will depend upon:

(i) Maintenance of freedom from the major animal plagues by effective import examination of animals and their products, continuing and developing international disease surveillance and supporting international disease control schemes.
(ii) Systematic application of known preventive and remedial agents for specific diseases.
(iii) In all animal enterprises the evaluation, diagnosis and treatment of inapparent or mild clinical disease by examination of strategically directed records of animal performance, for example, in breeding or in yield of final product.
(iv) The development in pigs, and possibly in poultry, of breeding nuclei free of specific disease.

The aim for the 1980s should be not only to increase production in quantitative terms, but to improve its efficiency and the quality of the product. All are dependent upon a high animal health status.

The livestock industry and animal health are fortunate in that their developing pattern one which could lead naturally to a possible structure for the 1980s. In many ways Great Britain has attained the objectives of the Mansholt plan for the E.E.C. of larger economic farming units operating with reduced labour forces. Over the last 20 years there has been a steady diminution in the numbers of farm workers (figure 1), a loss of agricultural land to urbanization and industry (figure 2), and increase in size of dairy (figure 3), pig (figure 4) and poultry units (figure 5) with a corresponding diminution in the number of units. These trends will continue, with animal production becoming more intensive and controlled whether in housed systems, as is likely to be the case with pigs and poultry, or on open pastures as with cattle and sheep. There are also taking place qualitative changes in the nature of the labour force in that a higher degree of personal training, skill and management capacity is necessary in intensive methods and there will be growth in ancillary expert services, for example, in farm economics, crop management and veterinary advice. Apart from truly natural areas which may be visualized as national parks with controlled sheep and deer production, general agricultural development will be governed by consideration of aesthetics and controlled urbanization which itself may be qualified by as yet unvisualized demands for our improved quality of living. In highly developed countries, such as our own, it may be necessary to find niches for the development of quality and unusual products, such as special types of beef, poultry, pigs, fish, rabbit and venison, to satisfy a sophisticated market demand.

There can be no doubt that control of eradication of animal diseases has, and will, lead to increased animal production and, perhaps more important in developed countries, to an increased efficiency of production which will enable the farmer to obtain the same economic return with a smaller number of animals. There have been many attempts to estimate losses from animal disease and much discussion has been generated on the difficulties of obtaining data and the problems of their interpretation. For present purposes, the modernization of a reasonable figure of 10 years ago of 15 % of total agricultural production will suffice (Beveridge 1960). Livestock products constitute 60 % of total agricultural production (Whitaker 1973) and a conservative estimate of 10 % loss due to disease provides a total financial loss of approximately £150M. It does not follow, of course, that removal of the disease element would result in a comparable saving, since labour of treatment, control, medicaments, various services and economic competition for resources must be set against this, but we are dealing with a large loss in which methods exist to effect considerable improvement in production. The overall conclusion can be supported with estimates for certain diseases and syndromes and sometimes in relation to individual enterprises. Such figures will emerge in subsequent discussion.

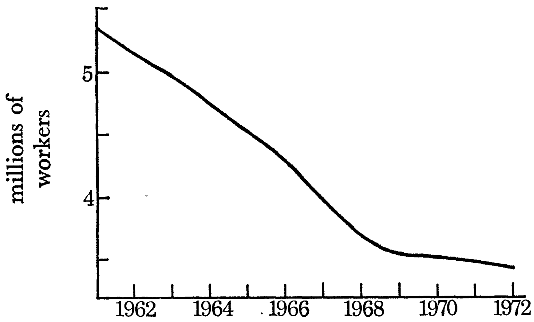

Figure 1. Decrease in number of agricultural workers.

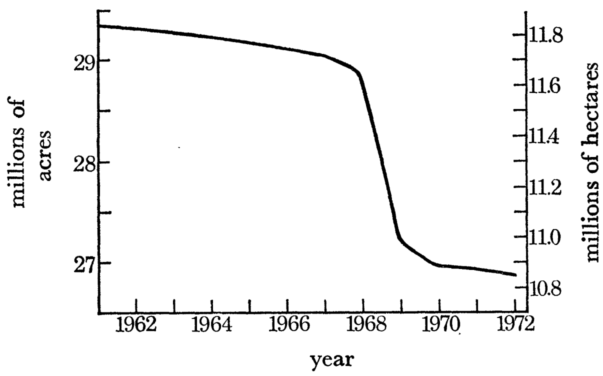

Figure 2. Loss of agricultural land.

The impact of impaired animal health on increasing productivity in the 1980s is conveniently considered on a graded scale of severity of diseases. First are those with high population mortality and involvement, for example, rinderpest, then specific bacterial, viral and parasitic diseases which can at times produce very heavy losses in individual enterprises and, thirdly, the type of disease which manifests itself chiefly by obvious or subtle impairment of production. This type may be caused by infectious agents, parasites or faulty nutrition acting either singly or in combination, and be dependent upon environmental and other factors for their expression. Finally, brief consideration will be given to the disease-free animal and the quality and qualitative nature of animal products. Only the major production species will be considered but there is no doubt the 1980s will be increasingly concerned with health problems in intensively maintained rabbits, mink and fish.

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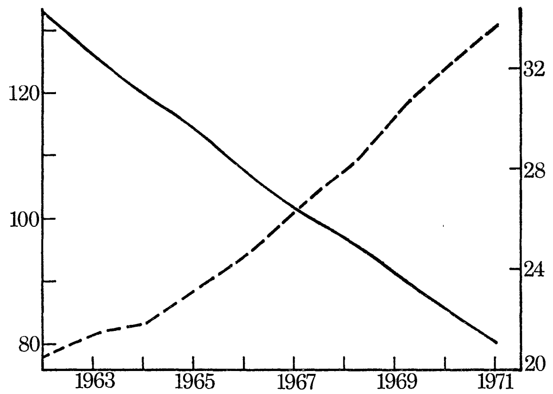

FIGURE 3. Number and size of dairy herds.

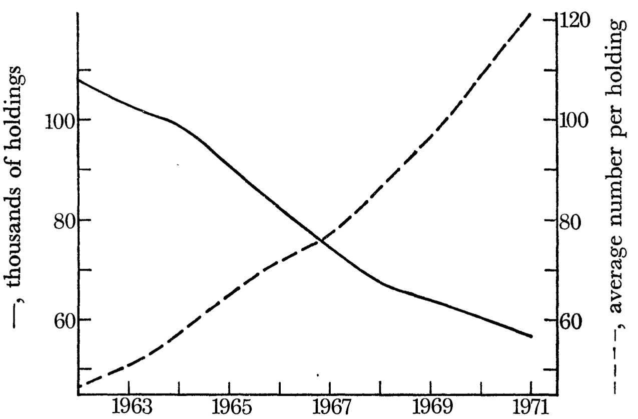

FIGURE 4. Number and size of pig herds.

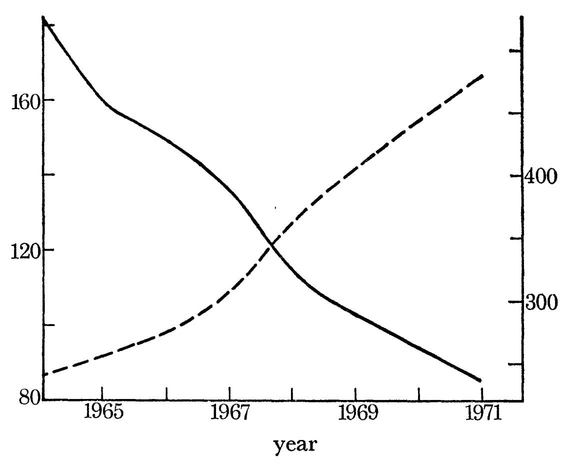

FIGURE 5. Poultry: number and size of egg-laying flocks.

1. Major epidemic diseases

There is now no reason why the occurrence of the more extensive animal plagues should be tolerated and it is to be hoped that in the 1980s many countries, and particularly those of Western Europe, will be completely free of them. We have a magnificent record in the United Kingdom of eradication of foot-and-mouth diseases, cattle plague, swine fever, contagious bovine pleuro-pneumonia, sheep pox and bovine tuberculosis. Despite the large volume of importations of meat and the introduction of livestock, efficient world disease surveillance, prompt intelligence, and the alertness of the veterinary service have maintained us on a disease-free plateau, but it should be recognized that vigilance must continue and that our security will increase with extended world freedom from these diseases. The present picture in the E.E.C. in terms of presence or absence of such diseases is presented in table 1, but it should be recognized quantitative differences exist. For example, sheep scab in England is a temporary sporadic outbreak being rapidly obliterated, and brucellosis in Italy does not constitute a major problem because of the housing of dairy herds while the amount of swine fever or of foot-and-mouth disease in France is negligible. The advantages are clearly shown by swine fever eradication and there are signs of an emerging desire to eliminate the disease from Western Europe.

Table 1. Presence of major epidemic disease foci in the E.E.C.

	foot and mouth	brucellosis		sheep scab	swine fever	t.g.e.	Newcastle disease
		cattle	pigs				
Belgium	−	+	−	−	−	+	+
Denmark	−	−	−	−	−	+	−
France	+	+	−	−	+	+	+
Great Britain	−	+	−	−	−	+	+
Irish Republic	−	+	−	+	−	−	−
Italy	+	+	−	−	+	+	+
Luxembourg	−	−	−	−	−	−	+
Netherlands	+	−	−	+	+	+	+
W. Germany	+	−	−	−	+	+	+

The financial advantage, general improvement in hygienic production and removal of the public health danger brought about by tuberculosis eradication is indicated by the estimate that the massive expenditure of £110M has been recouped in the short space of 15 years and the annual recurring bonus is of the order of £10M per year (Beveridge 1960). A recent rigorous examination of swine fever eradication (Ellis 1972) which was completed in 1966 estimates that the saving from 1963 to 1975 amounts to £37.5M, a figure which does not include the benefits of reduced suffering in pigs, improved food conversion, freedom from health restrictions, easier diagnosis of other diseases, expansion of herds and intensive systems, improved export potential and a disease climate which permits a more effective national pig health scheme.

Three accepted diseases of the group occur in Britain, namely brucellosis or contagious abortion in cattle, Newcastle disease in poultry and transmissible gastro-enteritis of pigs. A national scheme for control of brucellosis was initiated in April 1967 to establish a register of brucellosis-free herds as a preliminary to consideration of final eradication. The gross margin per cow in small groups of herds with and without brucellosis is shown in table 2 and demonstrates the advantages of freedom from the disease (Croxton 1972). About 37 % of herds and 50 % of animals are within the two succeeding versions of the national scheme, well over 60 % of the national herd is free of the disease and several areas for final eradication have been declared. The time necessary to attain complete freedom is difficult to predict, but it is to be hoped that the beginning of the 1980s will see complete eradication.

Newcastle disease for many years was controlled by means of a dead vaccine. This was most effective but rather expensive to prepare and, in addition, required inoculation of individual birds. In 1970, it was decided to permit the use of live attenuated vaccines. Systematic application undoubtedly controls the disease, but the very close profit margins in broiler and egg production mean that where disease incidence is low, use of vaccine is neglected and a dangerous situation of serious outbreaks can arise. Eradication on the initiative of either industry or government would not be an easy task, but a common aim in Western Europe of an effective 100 % vaccination programme to cut down circulation of virus and maintenance of a high degree of security of hygiene in poultry production units could pave the way to ultimate eradication. Control by live vaccine as a preliminary to eradication may be possible, as in the case of rinderpest, but the ideal would be a dead vaccine capable of mass application. There is scope for research in this field.

Table 2. Advantages from brucellosis eradication

	brucellosis-free non-accredited (38 herds)	brucellosis-free accredited (65 herds)	brucellosis 10 % infected (30 herds)	advantage
gross margin (£/cow)	80	93	69	24
milk yield litres (gallons) per cow per annum	3500 (770)	3710 (817)	3235 (711)	482 (106)
net herd replacement costs (£/cow)	8.8	6.2	12.5	6.3

The final disease in this group we must consider is that of transmissible gastro-enteritis (t.g.e.) of pigs. Originally recognized in the U.S.A. in 1946, its existence in England was suspected in 1956, and the first severe epidemic occurred in East Anglia in 1958. There have been successive waves in 1964–5, 1970 and 1971. The disease could be described as an emerging one and losses in young pigs can be heavy. The decision to live with a disease or eradicate it is one that is not always easy, and generalization is not possible; each disease must be considered on its merits. Whatever the ultimate approach to t.g.e. there is at present a need for the development of an effective vaccine and a clear appreciation of how much can be done meanwhile in preventing infection of herds by relatively simple hygiene. The virus is a delicate one and, even if eradication is not achieved, effective control by the 1980s is perfectly possible.

The final word in control of all diseases of the major epidemic type lies in effective import surveillance, prompt reporting, and a rigid application at all times of simple hygiene much of which is already laid down in statute. The measures are simple, but their observation and enforcement could lead to a greater productivity by diminution of disease transmission in a way perhaps less impressive but more effective than many scientific developments.

2. Specific diseases

For most obvious diseases of this type, means exist for effective diagnosis, prevention by vaccine or treatment by drugs, or antibiotics. Essentially, they are problems of individual farms. Their effect should not be minimized but, with certain exceptions, they do not lend themselves to a concerted nationwide effort leading to a marked overall effect on production.

Examples of this type of disease in cattle are actinobacillosis, vibriosis, herpes mammilitis, anthrax, mycotic abortion, blackleg, fascioliasis, infectious bovine rhinotracheitis and fluorosis. In sheep, vaccines exist for the clostridial diseases, such as lamb dysentery and braxy, enzootic abortion can be prevented by vaccination and pregnancy toxaemia by attention to diet. In pigs, examples are clostridial infections, swine erysipelas and mange, but relatively few major problems of parasitism exist which cannot easily be dealt with as a herd problem. In poultry, Marek's disease is an excellent example of a disease which has been mastered by an effective vaccine and, were it not for effective coccidiostats, modern intensive broiler systems would be impossible. Such uses will continue into the 1980s, but it may be necessary to develop new coccidiostats to cope with the development of resistant strains.

Parasitic diseases of cattle and sheep could readily be considered under 'diseases of production', but several may cause acute disease and death and are etiological entities. They are not of a type which could readily be eradicated and, although effective control methods exist, there is need for their extension and a greater appreciation of their effectiveness to secure a steady increase in production in the 1980s.

The liver fluke (*Fasciola hepatica*) can produce a chronic disease in cattle but is notable for the heavy loss it can cause in sheep following a wet summer. One estimate gives a total financial loss from fascioliasis of £50M per annum, a figure greater than that for mastitis (N. McWilliam 1972, personal communication). Obvious and subclinical losses could both be considerably diminished by a combination of meteorological, anthelmintic, land drainage and snail destruction techniques and there is room for considerable production increase in this way. A new selective molluscicide, in combination with other anti-fluke measures, hints at the possibility of eradicating fluke from a farm and, if experiments at present under way are successful, the 1980s may see the disappearance of the problem of fascioliasis.

Parasitic bronchitis of cattle (*Dictyocaulus viviparus*) is frequently the cause of acute respiratory disease in calves and in its anaphylactic form in adults, while the stomach worm (*Ostertagia* chiefly) can cause acute anaemia with wasting and death in calves (Michel 1969). The corresponding respiratory disease of sheep (*D. filaria*) is of less importance but the stomach worms of sheep can cause death (*Cooperia circumcincta*) in lambs and sometimes in adults (*Haemonchus contortus*).

These conditions lead to widespread and insidious losses and merit widespread attack.

Towards the 1980s there will be a trend towards the use of feedlots in which grass and forage crops will be hauled from fields to buildings in the growing season and from adjacent clamps and food stores. Under these systems there is a tendency for helminth problems to diminish, but in the extensive high stocking systems which will continue to be used in commercial breeding herds, close integration of pasture and animal management should permit anthelmintics to be used minimally and largely as an added security.

There are four important specific diseases which deserve individual consideration. The first, bovine enzootic leukosis, is certainly absent from the U.K., while the remaining three, scrapie and jaagziekte of sheep and leukosis of poultry are capable of increase to a level likely to be demonstrable in the 1980s and could produce a slow insidious interference with production. All these diseases are of obscure etiology and much remains to be learned about presumed or suspected causation. They all merit continued research and continued surveillance.

Bovine enzootic leukosis. The tumour form of leukosis is of little importance and it is that exhibiting leukaemia, i.e. enzootic leukosis, which constitutes the danger. Although absent from the U.K., certain European countries are conducting campaigns against the disease where general and focal incidences can be high.

Freedom in the U.K. must be assured and there is a strong case for continued vigilance. Techniques of establishing freedom need not be considered in detail here but a usual approach involves abattoir surveillance with follow-up of suspected cases to their herd of origin. Tests for the disease are always carried out on animals imported from enzootic areas. The economic significance of the disease is indicated by the fact that currently control in Denmark costs £400000 per annum, while loss in the United States is estimated (1968) at £600000 annually (Anon 1968).

Scrapie is a chronic fatal transmissible disease of sheep characterized by symptoms caused by the degenerative changes in affected brain. Much work has been done on the disease, but a major recent advance suggests transmission and contamination of pastures at lambing. Combined with very recent signs of a diagnostic method (Field & Shenton 1972) we may be able to develop control methods for this insidious disease which could be of importance in intensified production, improved productivity and removing an obstacle to the export of sheep. There is need for intensified research on etiology and epidemiology.

Jaagsiekte is a chronic condition affecting the lungs of sheep and which leads to respiratory distress, emaciation and death. The incidence is low but like scrapie we need to know more of its characteristics and it could be of importance in intensive sheep husbandry in the 1980s.

The avian leukosis complex includes primarily those diseases which are characterized by autonomous proliferation of essential blood-forming cells. At present the leukosis complex tends to be obscured by respiratory disease and is not regarded as a problem but it has potential with other diseases of this group to develop into a disease producing major losses. The most profitable approach is probably a genetic one, with breeding for resistance and survival capacity combined with improvement in the hygienic conditions of maintenance and breeding.

In summary, this group of specific diseases consists largely of preventable or curable diagnosable conditions appearing sporadically and amenable to veterinary treatment; three conditions susceptible to national or partly national campaigns, and four diseases which constitute a potential danger and are worthy of research and increasing surveillance.

3. Diseases of production

The term 'production disease' has been used recently to define with precision syndromes such as milk fever and ketosis in the dairy cow previously classified as metabolic disease (Payne 1972), but the heading 'diseases of production' is used in a wider sense to cover all conditions of cattle, sheep, pigs and poultry which manifest themselves by a low percentage mortality and relatively mild clinical signs, but which even in absence of obvious clinical symptoms can be detected by loss in productive capacity in terms of such factors as reduced gain in weight, or milk production or extended calving intervals. Looking at an animal production system as a whole (Morris 1969) one may be faced with a situation in which the enterprise is not making a profit although there are no obvious disease or management problems, a specific disease problem may have become apparent, but treatment does not result in the desired economic improvement, or the acceptance of an apparently small loss in mortality is concealing a much greater one in production. The major problem is identifying the area of loss, whether in overall management, in facets of food production and purchase, or in the component of animal health.

These problems are indeed already appreciated by stock owners, particularly those involved in large enterprises and the key to their solution is emerging in the greater use of effective recording systems, whether in the systematic examination of certain components of animal performance or in simple financial breakdown capable of speedy assessment by management.

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It is perhaps worth stressing that even more than in the past the veterinarian will require specialized diagnostic skill in recognition of clinical disease patterns and in use of laboratory tests; that record examination and wider consultation is not a substitute for, but an extension of, his diagnostic senses.

It is with reduction in impact of diseases of production that the greatest increase in productivity in the more developed countries can be expected to come. Diseases of this type will usually, but not inevitably, be of multiple causality and their manifestation will depend on the operation of a number of interacting factors. Individual cases will have their own problems each requiring analysis to improve profitability and productivity (Morris & Blood 1969). However, these individual needs do not prevent us from selecting from the knowledge and statistics available the diseases of production deserving special attention and whose diminution will ensure a steadily increasing production rise towards and within the 1980s.

The most important diseases of production are most conveniently dealt with on a species basis and are summarized in table 3. It is worth noting in passing that the appreciation of mastitis, infertility and brucellosis as diseases of economic importance is not new, and a voluntary control scheme was produced by the veterinary profession in 1941 (NVMA).

Table 3. Diseases of production

cattle	(1) mastitis
	(2) production disease
	(3) respiratory disease
	(4) calf losses
	(5) infertility
sheep	(1) abortion and perinatal losses
	(2) nutrition
	(3) pneumonia
pigs	(1) enteritis
	(2) reproductive problems
	(3) respiratory disease
poultry	(1) respiratory disease
	(2) coliform and other Gram-negative infections

(a) *Cattle*

(i) *Mastitis*

The losses from mastitis are of the order of £30M per annum and each herd constitutes a unique problem. Action has been initiated by the Ministry of Agriculture in cooperation with the dairy farmer, Milk Marketing Board, pharmaceutical firms and veterinary practitioners in the form of 'the mastitis awareness scheme'. It is too early to predict the success of the campaign, but it represents the general approach which must be taken to increase productivity in certain selected areas, namely the estimation of production losses, the stressing of simple measures to diminish loss, and the recognition by the producer of the need for professional expertise to analyse the problems of individual cases.

The financial advantage which can accrue to a herd with a low incidence of mastitis has been demonstrated in a useful study in which 25 herds with low mastitis incidence as indicated by low cell count of milk are compared with 25 herds with high cell counts. There was a clear average financial advantage of £29 per cow per lactation in the low mastitis group arising from an average better lactation yield difference of 825 l (182 gal). Of even greater interest was the detailed analysis of herd practice summarized in table 4 adapted from the paper by Pearson *et al.* (1972) which indicates the limitations of simplified advice, the need to consider herds as individual problems and the importance of overall good management. The low mastitis group showed a higher percentage of herds with a better approach to various components of management.

Whether estimated on a national basis or on a relatively small sample group of herds, improvement in mastitis incidence could lead to significant productivity increase and improvement in the quality of milk.

Table 4. Factors involved in mastitis control

		herds with low cell count	herds with high cell count
herd description	number of herds	25	25
	cell count, cells/ml	290000	1250000
	yield, litres (gal)/cow	4460 (981)	3630 (799)
	gross returns per cow	£144	£115
percentage using standard scheme recommendations	teat dipping	80 %	20 %
	efficient milking machines	68 %	16 %
	dry cow antibiotic therapy	68 %	68 %
use of management aids	efficient drying off (abrupt)	52 %	12 %
	bulk milk *Str. agalactiae* +	0 %	48 %
	maintaining records	56 %	12 %
	satisfactory holding yards (numbers)	19	8
standard and satisfactory methods in	udder hygiene	yes	yes
	insemination	yes	yes
	general management	yes	no
	culling practice	yes	no
	buildings	yes	no

(ii) *Production disease*

The term 'production disease' is new and links together all syndromes hitherto classified as metabolic diseases (Payne 1972). It is a special instance of the more general term 'diseases of production' which may occur in the course of any disease, and is associated with a break-down in high-producing animals of their homeostatic mechanisms due to aberrant inputs or outputs of key metabolites or to physiological disturbance in the animal.

Imbalances between nutritional input and output are reflected in blood chemistry changes and the use of the metabolic profile, namely simultaneous analysis for key blood chemicals, such as calcium, magnesium, phosphorus, albumen, sugar, ketones, globulins, and other constituents in a number of animals permits determination of a blood profile which by comparison with the normal profile can provide the clue to dietetic or management practices leading to production loss. Skilled interpretation is necessary and it is possible to deduce interaction between nutrients, nutrient deficiencies or even presence of infectious disease, and indicate the need for investigation of components of diet by classical food analysis procedures. The chief use of the test is to show how far the food input of the dairy cow is correctly balanced for production output, but the approach has further potential and is being applied using an extended number of analyses and in other species. Intrinsically the procedure is an economical one in that by automated biochemical analysis on one type of sample a large number of tentative, time-consuming and expensive individual analyses, e.g. of pasture, silage or milk, are avoided, although such analyses may be later required for confirmatory and remedial purposes. The approach has been made possible by automated high-speed analysis methods coupled with computer evaluation. The metabolic profile concept represents one of the major advances in detecting dietary production losses which are far from uncommon in the dairy cow.

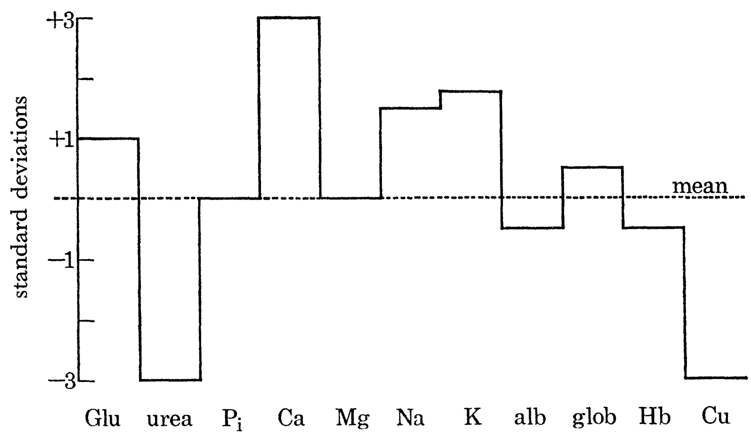

FIGURE 6. A metabolic profile.

Figure 6 is presented merely to demonstrate the principle and shows a profile histogram for a group of dry cows. The horizontal line indicates normal levels of blood constituents and the ordinate of standard deviations from the normal, a figure of 3 or more being taken as abnormal. The figure shows low urea, low copper and high calcium values. Low urea with slightly low albumen suggests rather inadequate protein intake, while hypocupraemia is not uncommon in dry (heavily pregnant) cows in late autumn coming off grass and may be accentuated by kale feeding. The high calcium, together with the normal inorganic phosphate level and slightly low haemoglobin levels, suggest that the samples were obtained in autumn from kale-fed animals.

(iii) *Respiratory disease*

The last 10 years have seen considerable advances in our knowledge of respiratory disease in cattle and we have fairly complete knowledge of the types of virus involved and the incidence of disease caused by the different types. This knowledge has led to the development of multiple viral vaccines whose effectiveness in the field is rather difficult to assess, but perhaps the most valuable information is that acquired on the importance of colostral immunity, the appearance of disease with declining colostral antibody and the importance of bacteria and environmental factors in producing overt illness.

More research is needed in studying the interactions of this multi-component system, but we have enough knowledge to reduce considerably the incidence of clinical disease and subclinical losses. The problem deserves to be considered in similar terms to mastitis with the application of a simple code of practice, which in fact exists, for dealing with the correct use of colostrum and improvement in the methods of trafficking in calves.

(iv) *Calf losses*

Respiratory disease is a significant problem in the older calf of 2–6 months of age. The major problems in the younger calf are enteric and related to *B. coli* infection and *Salmonella dublin* infection. For the latter a vaccine exists, while for the former the general principles enumerated for respiratory disease apply. An effective *E. coli* vaccine for calves is needed and recent developments involving stimulation of local immunity are promising.

The major contribution to increased productivity would be to take into account the individual characteristics of a variety of calf diseases, chiefly respiratory and enteric, and avoid their development by altering management practice.

(v) *Infertility*

The most realistic index of cow or herd infertility is the length of the calving index, i.e. the interval between successive calvings in days, and extension of this period leads to a loss of annual milk yield per cow, reduced numbers of calves and unnecessary costs of maintaining non-pregnant cows. Based on Milk Marketing Board data the present national calving interval for dairy cattle is considered to be approximately 394 days leading to an average loss of at least 29 days per cow due to impaired productive efficiency. A conservative overall estimate of monetary loss would be £83M (I. B. Munro 1972, personal communication).

The individual herd figure in table 5 shows that based on 1972 figures a reduction in calving index can increase profitability by £22 per cow for an average annual cost of 0.60p per cow (Martin 1973).

Table 5. Reduced calving interval and profitability of dairy herds

	herd A	herd B
number of cows	100	100
calving index	12 months	14 months
av. lactation length	305 days	386 days
av. lactation yield, litres (gal)	4320 (950)	4590 (1010)
av. annual yield, litres (gal)	4320 (950)	3940 (866)
value of additional milk and calves	£2198	

As far as is known, the problems in this area are largely of non-infectious origin, indeed in the case of abortion itself we can only effect diagnosis in about 15 % of cases. Infertility can be related to early embryonic deaths, reduced fertilization rates, diminution in behavioural oestrus, lack of detection of oestrus and a variety of other causes linked with trace element or nutritional deficiencies. The most obvious improvement could be made by more effective heat detection.

Of greatest importance in diminishing losses towards the 1980s would be the general maintenance of records showing the reproductive performance of each animal. If such were available, differential diagnosis could be more readily made and appropriate treatment applied or improved management suggested.

(*b*) *Sheep*

The pattern of development in the sheep industry is not so easy to discern as in cattle, pigs and poultry and the species tend to compete with other forms of agriculture. In lowland flocks there is a continued movement towards intensivism and this trend is also evident in hill areas where increasing numbers of flock owners bring their ewes in for lambing and fatten the lambs indoors (David 1969). Disease problems are dealt with as flock problems, rather than those of the individual animal, and as yet there is only limited measurement of flock productivity.

The problems of major importance are metabolic disease (production disease) resulting from faulty nutrition, pneumonias and reproductive disease and abortion. Lambs may be born prematurely or die soon after birth due to faulty nutrition of the ewe, but many losses are caused by infectious agents such as *Vibrio fetus* and the organism of enzootic abortion. *S. abortus ovis*, specific for the sheep can cause abortion, while *S. dublin* originating from cattle shows danger of being established in sheep.

The greatest contribution to production would be routine and periodic flock examination, paying particular attention to reproductive and metabolic disease and ensuring the systematic use of appropriate vaccines and anthelmintics. In intensivism to date there have been few manifestations of expected problems of disease, but there is a real need to establish flocks free of the insidious conditions of scrapie, Johne's disease, Border disease and jaagziekte.

(*c*) *Pigs*

The pig and poultry industries have much in common in their current and expected development. Pig units are large, more specialized in concept and not necessarily linked to agriculture, genetic development is considerable and there is a general movement to integration of enterprises and industrialization. There are also differences between the industries which arise indirectly from the size of animal and lead to differences in the degree of intensivism. Disease does not therefore spread so rapidly in pig units, different control methods are possible and exclusion of disease from a unit is not so difficult as with poultry. Very large units exist in Europe of 6000 to 10000 sows, but for a variety of reasons the unit in the United Kingdom is unlikely to rise above 500 sows (Alexander 1971).

The industry is in a state of some uncertainty in seeking the most desirable system for economic production. Systems may be roughly classified as:

(1) *Experimental.* High cost–high output systems which use minimum disease and caesarian derived stock coupled with zero-weaning and cage-rearing.

(2) *Extensive.* Few in number but sows and piglets are kept on open range, require minimum attention and care, obvious disease is absent but production is low and not monitored or controlled.

(3) *Convential.* In this type of herd there is no special health status and no production targets. The system is essentially intensified production with the ordinary pig herd.

(4) *Closed herds.* In these there is a nucleus herd of high health status, multiplier herds for expanding numbers of genetically proven boars and sows and the production herd which produces and carries out the fattening process. The nucleus stock may be caesarian derived or of minimal disease status.

On present evidence the last, closed herd system, seems the most suitable for increasing production in the future but there is considerable scope for increasing production in large-sized convential herds by the diseases of production approach with examination for inefficient components and the application of specialized veterinary knowledge to determine and rectify causes of diminished efficiency (Goodwin 1971).

Probably the most significant losses occur through enteritis at birth or at weaning, impaired reproductive performance in sows and in respiratory disease including rhinitis. There is obviously need for continued research but with enteritis, for example, there are a number of approaches which affect both response to treatment and profitability of treatment extending from consideration of the size of the unit, to the expense of antibiotics and the appropriateness of prolonged medication with arsanilic acid. Each case requires careful analysis to avoid use of drugs and unskilled use of food additives. Arsenicals can control dysentery, copper can increase gain in weight, possibly by acting as a trace element and anti-bacterial agent, but the aim should be to produce a balanced self-contained system with management as far as possible replacing expensive additives.

Reproductive performance and respiratory disease can also present comparable individual problems, and with enteritis merit concerted attack.

In the closed herd system, with minimal disease pigs the same diseases are of importance but less likely to appear with gross symptoms, the losses being largely those of production. If the health status is high, continuous monitoring is still desirable and should be particularly concerned with maintenance of freedom from mycoplasmosis and detection of entry of pathogenic enterobacteriaceae including salmonellae.

Much has already been done, but there is a continuing need for healthy, breeding herds of certified health status, not only in respect of specific diseases but in such elements as breeding performance.

In the selection of high production targets for the 1980s we should aim at:

(1) Elimination or control of t.g.e. which is of greatest importance in conventional high production herds which are not necessarily of high health status.

(2) Elimination of mycoplasma from nucleus herds of high health, specific pathogen free (s.p.f.) breeding stock and certification of their freedom.

(3) In s.p.f. herds priority should be given to the monitoring of production failure and should include examination for enteroviruses, parasitism, dietetic regimes and the study of sexual cycles. Major attention should be focused on nucleus and multiplier herds.

(*d*) *Poultry*

The disease picture in poultry arises from three major factors – an extremely high rate of intensivism, both in concentration of birds and geographically in concentration of units, the high incidence of respiratory disease and the extremely high infectivity of the respiratory infectious agents. The latter is probably a summation of the quality of the agents themselves and of the dust produced by bird feathers.

Respiratory disease, the major problem of intensive poultry production is the story of interaction between the viruses of Newcastle disease and infectious bronchitis, the live virus vaccines used to immunize against them, mycoplasma gallisepticum and strains of *Escherichia coli*. The last is ubiquitous but seldom becomes devastating without the presence of mycoplasma and the igniting effect of virus infection or vaccination. The whole approach to problems in poultry units is in the general terms of diseases of production. The principles are simple, the practice can be as complex as in the examples cited for bovine mastitis or porcine enteric disease. Considerable professional veterinary skill and specialized knowledge is necessary to put in motion the necessary hygienic measures and in ringing the appropriate changes in chemotherapy or vaccination to produce a more permanent production improvement. For the 1980s, consideration should be focused on three main areas.

(1) More effective methods of disinfection and general hygiene combined with unit dispersion, particularly in the broiler industry.

(2) A steady raising in the status of the health of original breeding stocks particularly the complete eradication of *Mycoplasma gallisepticum* infection.

(3) Complete population coverage with vaccines against Newcastle disease and infectious bronchitis.

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4. The disease-free animal

To obtain maximum animal protection free of infectious disease of man or animals the ideal would be the gnotobiote (the single organism or animal in isolation and unassociated with any other living species), or animal free of disease-provoking micro-organisms (specific pathogen free (s.p.f.). Among the production animals, the gnotobiote and s.p.f. pig historically takes pride of place – it was of convenient technical size compared with cattle, and the placenta proves a better barrier to parental pathogens than does the avian egg. S.p.f. herds of pigs have been established in North America, the United Kingdom, Germany and Switzerland, and it is most desirable that the number of such elite herds increases to provide breeding stock for more conventionally operated farms.

Earlier failures in caesarian derivation were largely due to inadequacies of technique, but although many groups have s.p.f. nucleus herd pigs it has not always proved easy to maintain complete freedom from pathogens, part of the failure being due to the very high degree of expertise needed to obtain isolation and the high capital investment necessary. Additional problems are the adjustment from an agricultural method of thinking to that of the very strict hygiene and environmental isolation of the s.p.f. herd, and to the marrying of economic production needs to the rigorous hygienic requirements.

Apart from a few specialized operations, and largely because of the ease of transmission of pathogens via the avian egg, s.p.f. poultry have not been developed commercially and the capital and development work necessary make it doubtful if it is a practical proposition even for the the 1980s.

Gnotobiotic calves and pigs can be produced cheaply for experimental purposes (£235 and £36 respectively compared with £95 and £27 for conventional animals) (Betts 1972). Such herds would be virtually free of all types of infectious disease and could constitute an ideal type of production animal for the 1980s and the future. The high capital costs, however, and the need for extensive development work make it unlikely funds would ever become commercially available and such a scheme would need to be regarded as a long-term agricultural development project needing very careful study before its initiation.

5. The quality of production

The plant is a more efficient protein producer than the animal and quantity-wise a competitor bound to win. It is unlikely wholly to replace animal protein in the foreseeable future, but is certain to be of great importance in developing countries and as a diluent for animal protein in cheaper foods in the more highly developed. Under these circumstances, we may have to visualize diminished or controlled degrees of animal production and an important feature in marketability or developing exports will be the quality and nature of the product, for example, meat from specialized high quality herds or certain species of fish produced under intensive pond or sea-cage conditions.

The absence of animal diseases transmissible to man in the flesh he consumes is manifestly desirable and indeed has a market value in itself. The effective control and eradication of such diseases (zoonoses) should be pursued with vigour, and at the same time as steps are being taken to break the chains of transmission, the likelihood of transmission should be diminished by reducing the mass of infective agent circulating in the animal population. The removal of tuberculosis is a very obvious example of this approach but much remains to be done with brucellosis, hydatidosis, cystercosis and salmonellosis, the last being one of the commonest forms of food poisoning. Diminution of salmonella infections in man does not lie in controlling a single factor or applying a simple control but in the approach to the 1980s devoting every attention to its control in livestock, the hygienic control of abattoirs and processing plants and continued education in the handling of food. Increasingly effective and highly skilled practice in carcass examination in abattoirs, including laboratory search for pathogens, tracing of disease to herds of origin, and full consideration of diseases found, whether transmissible to man or not should produce by the 1980s an extensive monitoring system for disease in the national herd and an even higher quality food for human consumption.

A discussion on quality would not be complete without mention of animal behaviour and animal welfare. There have been criticisms of intensive methods in animal husbandry, but it is not inevitable that intensivism leads to exacerbation of disease, nor that disease disappears or is absent under extensive conditions. Nevertheless, we still have something to learn of the optimum systems for the minimization of stress and for maximum production and results obtained might have unexpected effects on techniques of production in the 1980s.

Discussion

Animal health has been considered in the five areas of major epidemic disease, specific individual diseases, the important area of diseases of production, the possibility of disease free nuclei and the quality and efficiency of production. It only remains to summarize some of the thought behind the selection and the practical means by which increased production will come about in the 1980s.

(*a*) *Major epidemic disease*

The obvious devastating effect of these diseases led to action for their elimination. The current occupation with the micro-economics of farming enterprises leads to a tendency to dismiss them from our consideration or at most to consider them as melodramatic intrusions into ordinary agricultural production. But the tremendous loss in productivity they can cause and the need to control them on a global scale should never be forgotten.

A freer trade in animals is required between all countries in the world both for economic reasons and for exchange and introduction of new genetic material. Animal health needs are sometimes thought to be contrary to this trend, but in fact veterinary control authorities are well in advance of this changing situation in altering techniques of quarantine, and the development of new types of import/export tests.

International veterinary cooperation is well developed and, in addition to the development of new tests for specific diseases, much attention is being paid to the establishment and certification of disease-free herds and zones, certification of the origin of animals and of animal production. An adequately sized veterinary service is obviously necessary, and a high rate of awareness in all veterinarians and ancillary workers in checking and cross-checking the validity of certification in terms of both issue and receipt.

In an immediate outbreak the essentials are speed of diagnosis, and speed of controlling action, but perhaps most important of all is a continual and steady application of all regulations designed to minimize spread of disease, cross-infection and in the last analysis the tracing of animal movement. Every individual involved in the handling of animals should be acutely aware of the responsibilities he carries in respect of general disease control.

Just as public hygiene has supported advances in medical science and rid us of plague, smallpox and cholera, so can agricultural hygiene diminish the risk not only of severe diseases but of many lesser diseases of animals.

(*b*) *Specific diseases*

These exhibit the application of known, well-established cures or preventatives both by veterinary surgeons and by farmers themselves. There is need for more systematic application of what is known and district knowledge of disease appreciated before clinical problems are treated as isolated incidents. There are a multitude of specific diseases and conditions in which losses could be avoided by use of a very simple type of contract medicine with quite widely spaced and therefore economical visits.

The specific diseases of leukosis in poultry and ovine jaagziekte and scrapie need constant surveillance by veterinarians and stock owners. Their relatively low incidence means that at present they have little effect on productivity but a significant increase could diminish production and damage livestock trade in the 1980s. Safeguards should be maintained against the introduction of bovine enzootic leukosis.

Fascioliasis and helminthiasis deserve a concerted effort which if successful would pave the way to action in other specific but less obviously damaging diseases.

(*c*) *Diseases of production*

With individual enterprises the approach should be in terms of the profitability of the unit rather than in those of economic losses from disease or gains from health. With each species areas of importance are delineated, from which can be made a choice for specific action. This approach with, of course, determination of new areas as time advances, should be that of the future; the attack should be focused on areas of importance to agriculture as a whole.

The recognition of the problem may come from any source – the economist, the general farm consultant, the accountant, or, since he is most frequently on the farm, from the veterinary surgeon. But a major professional objective must be not only that of the whole farm approach involving a team of advisers, but a recognition by professional advisers themselves of the contribution which can be made by allied professions and experts to problem solution. A 5 % mortality loss may be quite acceptable to the accountant and represent little loss in profitability, but this small loss may represent a much greater loss to come. Equally, the seriousness of a mastitis problem may not be within the animal but be due to inadequate housing and collecting yard facilities. Profitability should operate in the long as well as the short term and should be compatible with the general and not only the individual upward trend in agricultural productivity.

(*d*) *The disease-free animal*

Production of this kind represents a more spectacular area of advance, but although many high-quality nuclei have already contributed to higher health standards, further advance will need much capital and must be left to the innovators. There is certain, however, by whatever means, to be greater effort to form groups free of many relatively minor diseases.

(*e*) *The quality of production*

This phrase includes the efficiency of production, the originality of food, its health significance and the conditions under which animals are maintained. Most important is that monitoring for

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high quality and the presence of animal disease is a most effective means of maintaining high productivity and ensuring a continual surveillance of the state of animal health.

In conclusion, improved animal health can lead to more efficient livestock production in the 1980s. From the scientific aspect this will result from better vaccines, improved diagnostic methods and epidemiological studies and from an increasing knowledge of techniques for costing disease and examining interactions in the host/parasite/environment system. However, most benefit will be obtained from coordination of effort in the diseases of production and more effective application of existing knowledge. Action in both areas will be stimulated by an increasing economic pressure which will militate against the survival of units with stock of other than high health status. In addition, there will be an increasing demand for high-quality products by the food industry, public and government.

Much of the increased production will come from the efforts of individuals but there must be a continuing recognition by industry and government of the need for animal health control on a regional and national basis and in the long and short term. A high health status of livestock in the industry as a whole is the concern and to the advantage of all involved.

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Discussion

W. R. Smith (*Agricultural Development and Advisory Service, Great Westminster House, Horseferry Road, London S.W.*1). Dr Paterson has presented a picture of what he forecasts will be the health status of the livestock of this country in the 1980s. He has also identified problems which are now being tackled and which will continue to demand the attention of research and development workers and advisers over the next decade.

The first point I would make is that the basic structure of the industry changes relatively slowly. Although large farming businesses have developed, particularly in arable farming, we will continue to have a numerically and economically strong family farming sector engaged in livestock farming. By the 1980s even the economists will have learned that so far as livestock is concerned, the problems of scale outweigh very often the so-called economies of scale! Of course there will be more large-scale intensive units, but they will not by any means monopolize the situation. It is certain that livestock output per unit of land and per man will be intensified which in itself exphasizes the need to control diseases and disorders associated with high stocking density whether on land or in buildings.

My second point is that contrary to popular belief farmers are not slow to adopt the findings of research and development. They do so when the economic circumstances are right and if the development provides a substantial return for investment. It is a fact that those developments which are easy to incorporate into production systems are readily taken up, but where capital investment is required, particularly in buildings, then changes take place much more slowly.

My third point is that whether units are large or small, livestock production systems will be more specialized and greater precision in their operation will be applied in the 1980s. Overall farming systems will be more diverse, especially on large farms, than in the 1960s because in a situation of greater dependence on the market for his returns the farmer will prefer to sell three or four commodities rather than one or two. There will also be a marked trend for farmers to feed livestock from their own land so that they will be less dependent on world supplies of animal feed.

I have one question to ask of Dr Paterson. Because of the need for greater precision in livestock management, will the use of metabolic profiles be routine by the 1980s?

A. B. Paterson. It is doubtful if the use of metabolic profiles will ever become routine, but they may be applied in a wider range of disease conditions.