INTRODUCTION

The Australian pig industry is small compared with those in many other countries and with other rural industries in Australia. Pig production represents approximately 1% of the total gross value of rural production in Australia. Demand for pig meat is almost entirely for domestic consumption. However, the fortunes of the industry are affected by overseas conditions because the major input, feed grain, is tradeable and pig meats are largely substitutes for red meats, the prices of which are determined overseas. These factors are major but uncontrollable limitations to pig production in Australia. Similarly, domestic consumption of pig meat, although it has increased slightly in recent years, does provide a limit to pig production.

During the last decade there has been a continuing trend toward larger scale and more intensive pig production in Australia. The Bureau of Agricultural Economics (BAE 1979) estimated that the average number of pigs per holding has almost doubled between 1969 (56) and 1978 (110). While this trend offers obvious advantages in areas such as labour utilization, environmental control and economies of scale, new and perplexing problems have also been encountered.

Certain limitations to pig production arise from this increased confinement of pigs. These include off-farm factors such as the increased cost of supplying both fuel and food energy and also factors like urban-based pressure groups attacking the welfare and pollution aspects of intensive pig production. Limitations imposed through production inefficiency also arise because of factors such as those associated with health, nutrition, breeding and building design.

MARKETING

Pig meat consumption has risen by only 2 kg/head/year during the last two years compared with chicken meat which has risen from 12 kg to 24 kg/head/year in the same period. I believe that the variable quality of pig meat is inhibiting its acceptance. By contrast, the quality of chicken is more uniform which probably reflects more uniform methods of breeding, feeding and management.

Pig production is obviously more complex than poultry production but the first steps in providing the market with a uniform product are a nationally accepted standard of measurement of quality and price incentives to encourage
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producers to meet that standard. Poor quality carcasses are already difficult to sell and this underlines the urgency of this problem. National standards have already been proposed and are being adopted. The speed with which they are accepted and adopted and their ultimate value to the industry will depend on the price differentials between good and poor grades.

I believe the current differentials are poor incentives for the production of high quality pigs. The following simplified example serves as an illustration. Consider a producer with a 100-sow herd producing 16 pigs/sow/year and marketing 30 pigs per week at 60 kg carcass weight. If pigs are grown rapidly he can expect to receive $1.43/kg carcass and an annual income of $137,280 (1600 x 60 x 1.43). If food intake is restricted so that pigs are sold at 30 weeks instead of 26 weeks of age, production will drop to 1477 pigs/year but due to improved grading (Table 1) the average price received per kg will increase by five cents to $1.48. However, in the first year, income will fall to $131,158 (1477 x 60 x 1.48) because less pigs are sold. In addition, slower growing pigs require more accommodation which, on current costs of $50 per pig place, would amount to $6,150 (123 x 50).

TABLE 1 Effect of growth rate on carcass quality

<table>
<thead>
<tr>
<th>Carcass quality grade</th>
<th>Price/kg</th>
<th>Proportion of pigs in each grade (%)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Rapid growth (26 weeks)</td>
</tr>
<tr>
<td>I</td>
<td>1.50</td>
<td>40%</td>
</tr>
<tr>
<td>II</td>
<td>1.42</td>
<td>45%</td>
</tr>
<tr>
<td>III</td>
<td>1.30</td>
<td>15%</td>
</tr>
<tr>
<td>Average price /kg($)</td>
<td>1.43</td>
<td></td>
</tr>
</tbody>
</table>

On the basis of these figures it can be calculated that it would take about two years to regain the loss of income and capital investment due to a change to slower growing pigs. The price differential to induce a producer to make such a change would need to be at least 20 cents per grade.

The long-term approach is to improve the performance of our pigs through genetics by selecting pigs from within the national herd that are fast-growing and lean.

GENETICS

Pig producers are fortunate in that the relatively large litter size and rapid generation turnover of pigs give them the potential for faster rates of genetic improvement than any of the other large domestic animals. Despite this, there are limitations to achieving reasonable rates of genetic progress. Such progress depends on having large numbers of animals, keeping accurate and pertinent records, and being able to use these records sensibly. The use of computers is beginning to facilitate the task of record-keeping and retrieval and may reduce costs for those piggeries able to make use of them. Good records can be useful not only for the selection and breeding of pigs for characters such as growth rate and backfat, but also for tracing genetically-based defects and susceptibility to disease. So far this avenue has not yet been exploited to any extent. Large intensive units are ideally situated to make maximum progress in genetic gain and it is likely that in the future they will do more to exploit this situation. This will leave smaller producers free to concentrate on streamlining management for high output per man, obtaining superior stock from larger specialist units.
NUTRITION

We understand a lot more about feeding pigs now than 20 years ago and there are many examples of improved growth rates and carcass quality to verify this. However, we are still guessing at the optimum levels of many nutrients in the diet. Examples of areas requiring more research are to determine the ratio of dietary energy : protein and the proportions of essential amino acids within the dietary protein of pigs at various stages of growth or of pigs with different genetic potential.

Rising food costs, particularly of energy, necessitate the continuing search for alternative feeds.

ENVIRONMENT

I believe that many intensive piggeries are monuments to man's complete lack of understanding of the pig. Often pigs have been subjected to conditions which are not even fit for human beings! It is difficult to quantify the effects of adverse environments on the productivity of piggeries but there is ample evidence to indicate that it is important. For example, post-farrowing losses of piglets are often believed to have been caused by infective agents but it has been shown that the primary cause of susceptibility to infection is poor housing with draughts and chilling. The well-known, but poorly understood, syndrome of summer infertility is obviously associated with high temperatures. Strategic control of the environment could offer simple answers to these major problems. As the degree of intensification increases there is decreasing opportunity for the pig to modify its microclimate and, clearly, a greater demand for a controlled housing environment. However, more biological and engineering information is required before optimal environmental conditions can be economically provided within a pig house.

SOCIAL PROBLEMS

The fact that the pig industry is classified as an offensive trade puts it at a disadvantage. Pig producers near urban centres are coming increasingly under criticism from local councils, from whom they must obtain licences, and from environmentalists because of effluent disposal problems and possible pollution. This stigma may be carried over to a consumer resistance in some quarters to pig products themselves. We need scientific help in overcoming waste disposal, pollution and odour problems and the industry must work hard to present a new image.

Pressure from the animal liberation movement, which is increasing rapidly, presents a serious problem to pig producers which may limit future productivity. Most of the improvements in productivity and improvement in the quality of pig products are the result of intensification. Intensification is, of course, anathema to animal liberationists. Criticism from liberationists should be countered by the establishment of a national code of practice for pig production. The development of this code is already under way but much more research into animal behaviour is necessary so that we can prove to ourselves and to our detractors that our current practices are not detrimental to our animals.

All of the above problems are interrelated and the man who must co-ordinate new developments and technology toward making his enterprise more efficient and profitable is the producer. Although it is often forgotten by scientists, it is the producer's role, particularly as a stockman, which is often the most important of the current limitations to pig production.
It is essential that scientists apply themselves to solving problems created by intensification so that the producer can improve efficiency.

LIMITATIONS TO PIG PRODUCTION IMPOSED BY ANIMAL BEHAVIOUR

P. H. HEMSWORTH*

The intensified production of farm animals is commonly characterised by restriction in the animals' movements, space allowance and social contact. The behaviour of the modern pig's ancestor was genetically adapted to survival under extensive conditions and yet man, in requiring the pig to adjust to the artificial environment of the intensive farm, has neglected its behavioural needs.

Since it is most unlikely that genetic change in the behavioural needs of the pig is keeping pace with the rapid changes in the environment of the intensive farm, in the short term man must provide the animal with an environment that will suit its genetically-fixed behavioural needs. Failure to do so will cause serious disruptions in behaviour. Common behavioural changes of intensively-managed animals that are presently being observed can be classed as:

- **Type I** - normal activities prevented by the social or physical environment;
- **TYPE II** - activities not being elicited because of lack of key releasing stimuli;
- **TYPE III** - barren or complex, changing environment producing too little or too much stimulation.

It is the objective of this paper to identify several major areas in which intensive pig production can disturb the behaviour of the pig to the point of lowering productivity. Further, since the adoption or continuation of a management or husbandry practice should be influenced by both profitability and animal welfare, a practice that results in severe behavioural change may have to be discarded on humane grounds.

LIMITATIONS CAUSED BY BEHAVIOURAL CHANGE

Interference or inhibition of reproductive behaviour by the restrictive social and physical environment of the intensive piggery imposes severe limitations to productivity. Extended periods of restraint or confinement of the pregnant, farrowing or lactating sow appear to be associated with increased still-birth rate, poor piglet survival and poor sow and piglet health (Backstrom 1973; Anon. 1978). It is not known to what extent the maternal behaviour of the confined sow is disturbed by the lack of suitable bedding material and the reduced contact with her piglets. The extreme restlessness of some sows, which may cause injury or death to the piglets, may be reduced if more normal nest-building was permitted (Baldwin 1969). Baxter (1971) found that 46% of piglet losses in 117 U.K. units of 100 sows or more were due to crushing and yet 86% of these units used farrowing crates. In addition to the development of poor maternal behaviour, other factors such as lack of exercise, increased duration of farrowing and "stress", may be involved in these effects of extended confinement on sow productivity. The extensive survey by Backstrom (1973) also indicated that the size of the farrowing/lactating pen influenced piglet health and survival: the best results were achieved in pens with a floor area greater than 5 m². The influence of confinement on the development of parturient and

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maternal behaviour of the sow and on the neo-natal behaviour of the piglet urgently requires examination.

It is well documented that the social environment exerts a major influence on the sexual behaviour of the pig. Lack of social contact, particularly contact with the opposite sex, will adversely affect the sexual behaviour of both the post-pubertal boar and sow (Signoret 1970; Hemsworth et al. 1977). Lack of physical contact with pigs during rearing, as may occur in individual performance testing conditions, results in poor development of the sexual behaviour of the boar (Hemsworth et al. 1978). Also, lack of contact with mature boars during rearing produces poor oestrous behaviour and expression of oestrus in the gilt (Hemsworth and Cronin, unpublished data). Further, England and Spurr (1969) found that individual penning of gilts prior to mating may inhibit oestrous expression. Therefore, since intensive pig production often restricts social contact between pigs, reproductive inefficiencies may occur as a result of poor sexual behaviour.

The influence of group size and density on behaviour and productivity of growing pigs has been comprehensively reviewed by Syme and Syme (1979). Pigs housed with less than 0.6 m² per pig have reduced growth rate. Increasing stocking density above this point appears to be associated with increased aggression. The influence of group size is not as clear, however, there are indications of low growth rate in groups greater than 10 to 12 pigs. Maintaining a stable social order in dense or large groups is probably the limiting factor.

Tail-biting is of considerable economic importance (Penny 1974) and yet has received little scientific examination. It is often reported from industry experience that a barren, unstimulating environment leads to tail-biting. Physical, social and climatic environment, dietary factors and genetic factors are some of the causes suggested (see Ewbank 1973). Research is required to increase our understanding of this obscure behavioural disease complex.

The influence of the relationship between the stockman and the pig on animal productivity has been largely ignored in the modern piggery. However, a recent study by Hemsworth (unpublished data) of 12 identical one-man piggeries has demonstrated the importance of a good man/pig relationship. Reproductive performance was significantly higher at farms where this relationship was good. Factors influencing the relationship need to be identified but the quality and/or quantity of animal handling by the stockman may be an important factor.

LIMITATIONS CAUSED BY BEHAVIOURAL ASPECTS OF WELFARE

The pig industry must recognise that the welfare status of the pig will come under increasing scrutiny by the community. Husbandry practices that produce severe physical and mental suffering to pigs must be abolished. At present, there is a serious lack of information necessary to objectively assess the welfare status of the animal. However, with present and future research examining the behavioural, physiological and injury response of farm animals to intensive conditions, it is likely that in the near future an assessment of welfare status can be made based on objective and sound scientific information. From limited data, it appears that the most severe behavioural changes are observed in sows housed for extended periods on tethers or in stalls and, to a lesser extent, pigs housed in flat deck cages (Recommendations from-the First European Conference on the Protection of Farm Animals, Amsterdam, 1979). In both cases confinement and the barren environment, are most likely responsible for these changes. The reader's attention is drawn to the excellent review on welfare of intensive farm animals by Murphy (1978).
LIMITS TO PIG PRODUCTION IMPOSED BY FEEDING

M.R. TAVERNER

Feed supply and the efficiency of feed utilization both have a major influence on the costs of feeding pigs. Since feeding costs represent a large portion of the variable costs of pig production, these two factors will affect economic viability of a pig enterprise and provide an important limitation to production.

This paper will discuss the main limitations to pig production in Australia imposed by feed supply and by nutrition.

LIMITS IMPOSED BY FEED SUPPLY

The Australian pig industry is dependent for feed upon a number of other agricultural enterprises such as the grain, oilseeds and meat industries. Thus beef production may influence pig production through the supply of meat & bone meal. Meat & bone meal has been the major protein concentrate used in the Australian pig industry but a forecast decline of 16% in cattle slaughtering in 1980 compared with 1979 (BAE 1979) implies a reduced supply and a continuing high price for meat & bone meal. Furthermore, there is also a strong export demand for meat & bone meal; in 1976-77, 75% of the meal produced was exported and domestic prices increased 53% over this period (BAE 1979). The following year sow numbers in Australia were at their lowest level for the decade.

The grain market is another factor likely to limit pig production through increased feed costs. Domestic grain prices are determined both by developments in the local market, such as seasonal conditions, and by international events. However, there is a new development in feed grain marketing that will affect the supply and price of grain. For the 1979-80 wheat crop new marketing arrangements have been introduced under which the Australian Wheat Board has sole trading powers of wheat on the domestic market. The price of stock feed wheats (general purpose and feed grades) determined by the AMB in 1980 is substantially higher than that in previous years. This arrangement provides an incentive for wheat production and if it continues, will increase the availability of feed wheat relative to coarse grains. It should also provide an incentive for the production of the freely-traded feed grain, Triticale.

Average feed costs in Victorian piggeries increased by more than 40% between 1974-75 and 1978-79 (Table 2) and by early 1980 these costs had increased a further 10%. However, the extent to which this will limit pig production depends largely on the margin between returns from meat sales and feed costs (Table 2). Thus it seems that to maintain the current level of production, the industry is dependent on increased prices for pig meat.

<table>
<thead>
<tr>
<th>Average feed cost</th>
<th>Margin of meat price over food cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>($/tonne)</td>
<td>($/kg meat)</td>
</tr>
<tr>
<td>1974–75</td>
<td>94</td>
</tr>
<tr>
<td>1975–76</td>
<td>104</td>
</tr>
<tr>
<td>1976–77</td>
<td>125</td>
</tr>
<tr>
<td>1977–78</td>
<td>140</td>
</tr>
<tr>
<td>1978–79</td>
<td>134</td>
</tr>
</tbody>
</table>
The limitations imposed by rising feed costs can be overcome or delayed to some extent by the use of cheaper, less conventional feedstuffs. In Europe, for example, feedstuffs such as manioc are replacing cereal grain as energy sources in pig rations (De Boer 1980). Also in Australia, there are options to the conventional energy sources that range from the new feed grain Triticale to the use of root crops. Although there are factors in Triticale that might limit its inclusion in pig diets to levels less than other cereals (Erickson et al. 1979; Radcliffe, 1979), this grain is already included in conventional pig rations. Root crops on the other hand, are not widely utilized as pig feed partly because they are not suited to the common dry meal feeding system used in Australia. However, this feeding system in itself has been shown in numerous studies (such as Braude and Rowell 1967) to limit pig production relative to liquid feeding systems for which root crops are better suited. The use of liquid feeding systems also offers great potential for the use of cheap liquid wastes such as distillery and brewery wastes, whey and food processing wastes.

There are also alternatives to conventional animal protein sources for pigs. The increased cost of meat and bone meals and the decrease of almost 70% in fish meal supply during the last 5 years has increased the use of vegetable protein sources such as oilseed meals, peas and lupins. Oilseed meals are the by-product of the edible oil industry and in Australia their increased supply seems assured by the increased demand for oils and fats (BAE 1979). On the other hand, as the meat industry develops more efficient methods of recovering protein for human consumption from raw materials, it is likely that meat and bone meal supply and quality will decrease. However, Herbert (1979) has suggested that protein supplements from other abattoir by-products such as waste-activated sludge, may be developed to compensate this decrease. Other proteins such as leaf protein concentrate (Pirie 1977) and single cell proteins (Whittemore et al. 1976) may also become more available. The need for protein concentrates may even be reduced by the introduction of high lysine cereal grains and/or the wider use of synthetic amino acids. In particular, Harrison and Batterham (1978) demonstrated a considerable potential for the use of synthetic lysine in Australian pig diets in which lysine is normally the most limiting dietary amino acid.

LIMITS IMPOSED BY NUTRITION

Limitations to pig production due to nutritional inadequacies are generally less obvious than those due to feed supply. In the pig industry more than in many other animal industries, there is a high degree of control over nutritional conditions and acute signs of nutritional deficiency rarely appear. Rather, it is more often a problem of pig production being suboptimal because of nutritional inadequacy. In overcoming this limitation, the problem first needs to be recognised. Once a solution is identified, a management decision can then be made considering both economic and biological efficiency. Some of the more common causes of nutritional inadequacy are:

(a) diet formulations for levels of digestible energy and available amino acids that are inaccurate because of inadequate specification of ingredients. This is a problem of variation within a feedstuff as well as with an increasing number of new feedstuffs. Although the total levels of the major variables of nutritive value of feeds (energy and amino acids) can be chemically determined, unfortunately the availability of these nutrients to the pig varies among feeds and available nutrient levels are more difficult to determine. For example, Batterham et al. (1979) found only 50% of the total lysine in meat & bone meal was available to the pig as compared to nearly 90% in soybean meal. Furthermore, they found that the usual laboratory assays of lysine availability were not accurate and that this was best determined by animal feeding trials. Thus for many feeds there are inadequate estimates of lysine and energy status for pig
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rations which may constrain their inclusion in diets or reduce the accuracy of
diet formulation;

(b) failure to adjust where possible, nutrient intake to pig potential. Differences in potential can be recognized among pigs of different breed, strain and sex and appropriate discrimination in feeding can be made. For example, Taverner et al. (1977) found that levels of dietary protein that maximized growth rate of castrates were limiting to the growth rate of gilts; to fully exploit these differences the different sexes require separate feeding. Furthermore, it may be that in some climates where there is variation in feed intake between seasons, separate diets of different nutrient density may be required to maintain nutrient intake and subsequent growth or reproductive performance.

LIMITATIONS TO PIG PRODUCTION IMPOSED BY EFFLUENT DISPOSAL

M. J. GINNIVAN*

Piggery effluent is a concentrated source of pollution, a possible disease reservoir and a source of both energy and nutrients. The demand for effective management of effluent from intensive piggeries is increasing, particularly where the environment (including the work place) is, or is thought to be, in jeopardy. The inability to effectively manage pig effluent may, by virtue of both "on farm" and "off- farm" constraints, limit pig production. Surveys by Magarey (1977) and Parran et al. (1977) reflect the concern of pig producers while the often stringent and restrictive legislation at local and State levels serves to emphasise the extent of "off farm" opinion. Approximately 30% to 40% of the Victorian shires in which piggeries are established have or anticipate problems with intensive pig industries.

There is a variety of effluent treatment systems currently used in the pig industry. These include lagoons, separation and composting and mechanically aerated systems. Processes attracting increasing attention include thermophilic aerobic treatment and high-rate anaerobic digestion for methane generation. However, the land disposal of effluent remains the general objective and inevitable end-point of these treatment systems. The systems have been developed to overcome certain limitations to land disposal.

The objective of this paper is to discuss the constraints to land disposal imposed by certain hydraulic, chemical, biological and/or bacteriological factors and how failure to comply with these may limit pig production.

LIMITATIONS TO LAND DISPOSAL

HYDRAULIC CONSTRAINTS

The inability to comply with the hydraulic constraints governing land disposal of effluent may result in runoff entering watercourses. The water pollution that results exacerbates the problems of waste management often to the extent that profitable pig production is restricted.

Runoff is a consequence of effluent application rates exceeding soil infiltration rates. It is thus dependent on complex interactions between factors such as soil type, topography, vegetation, climate, method of application. In an attempt to formulate general guidelines for land disposal O'Callaghan et al. (1973) proposed to schedule applications to prevent soil saturation and hence runoff. Application rates were just sufficient to meet the soil water deficit

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Animal production in Australia which was determined from the difference between evapotranspiration and rainfall. Barker (1976) also proposed that decisions on land spreading of effluent be based on historical rainfall data. Indeed, current U.S. legislation governing waste disposal incorporates this concept, however the implications being that the acceptable frequency of runoff is once in ten years (Loehr and Denit 1977). Further, by 1983 waste runoff will be effectively prohibited since waste management systems will have to be designed to reduce the frequency of runoff to once in 25 years; the probability of runoff must be less than one in 9,125. Some of the problems associated with runoff are discussed below.

The potential chemical pollution resulting from pig effluent entering watercourses is significant. Levels of nitrate nitrogen in watercourses (W.H.O. max. 10 mg/l) have been reported to increase as a result of animal effluent disposal (Loehr 1974; Singh 1977; Strauch 1977). Although phosphate ions are quickly immobilised in soil, Keating and Dodd (1975) reported that the eutrophication of inland water was associated with land disposal of pig effluent. Davies (1973) has reported increased concentrations of copper in watercourses as a consequence of runoff from animal disposal areas. Copper in the ionic form is toxic to aquatic life even at concentrations as low as 0.02 to 0.08 ppm (Mount and Stephan 1969).

The oxygen demand of pig effluent is such that the degree of treatment needed to prevent pollution of watercourses is not generally available "on farm" without excessive cost. Approximately 99.9% of the biological demand (BOD5) and suspended solids must be removed from the effluent prior to discharge. Scott and Fulton (1978) have demonstrated and quantified the capacity of grass filtration to remove biological pollutants. However, the impact of pig effluent entering watercourses is likely to remain substantial.

Chandler and Craven (1978a) isolated an average of $5 \times 10^8 E. coli$ per ml of effluent from Victorian piggeries. Thus, one litre of pig effluent is able to pollute 5000 kl of recreational waters or 500,000 kl of potable water. Virulent salmonella and erysipelas organisms have also been identified in a significant proportion of pig effluents (Jones 1975; Wood and Packer 1972; Van Ness 1975; Jones et al. 1976). These organisms represent a threat to animal and public health should they enter watercourses even via drainage from effluent irrigated pastures (Evan and Owens 1972).

**CHEMICAL CONSTRAINTS**

Although there is considerable fertilizer value in pig effluent, application rates should not exceed the fertilizer requirements of the disposal area. Grazed pasture is an effective sink for effluent nutrients and O'Callaghan et al. (1973) proposed that best use of the fertilizer value of pig effluent results from applications of 500 kg nitrogen/ha/yr or 300 kg potassium/ha/yr. Higher applications increased nitrate nitrogen in herbage to levels capable of depressing animal growth rates (Hanway 1963; Blaxter 1968; Reid 1972; O'Callaghan et al. 1973). However, the often significant nitrogen losses prior to and during land application (Loehr 1974; Vanderholm 1975) and the variable efficiency of nitrogen uptake (O'Callaghan et al. 1973; Skarda 1975) means that potassium rather than nitrogen may be limiting despite the higher concentration of the latter in freshly-voided effluent. Potassium uptake by grass is high (Rogers 1967), particularly during active growth and heavy effluent applications could lead to hypomagnesia (Rogers 1967; Fontenot et al. 1973) and damage to the sward (McAllister 1971).

Increased salinity and copper levels are among other chemical constraints limiting heavy applications of effluent to land. Indeed, Jeffery and Uren (1978)
reported a ten-fold increase in electrical conductivity in soils after five to seven years of effluent applications. The resultant increase in salinity would depress pasture yields and exclude salt-sensitive species such as clovers.

Copper in effluent from pigs given up to 250 mg/kg DM as a growth promotant increased the copper content of herbage when applied to land (Batey et al. 1972; Woodside 1973; Lexmond and de Hann 1977). However, if effluent is applied at rates equivalent to 500 kg nitrogen/ha/yr (even assuming 30% nitrogen loss) the copper applied to land will be less than 50% of the 9.5 kg/ha/yr suggested by Batey et al. (1972) as a safe maximum. If higher applications are made, particularly without prior sedimentation (Hussiany 1978), then levels in herbage could increase despite preferential storage by roots (Jarvis 1978) and the rapid immobilisation of copper by soil and organic matter. Copper in pig effluent is available to sheep (Dalgarno and Mills 1975) and may represent a problem for breeding stock grazing disposal areas for a long term. This is particularly relevant in drier areas with sandy soils (Jeffery and Uren 1978) where effluent is not washed from pasture (Batey et al. 1972). The potential toxicity associated with heavy application of copper is exacerbated by low molybdenum levels in soil and low dietary concentrations of zinc and iron.

In summary, it would appear that correct land application of effluent enables a good pasture response but when application rates are excessive the accumulation of nitrates, phosphates, potassium, sodium or copper may limit land disposal.

Bacteriological Constraints

Ultimately land disposal of effluent is only acceptable if the disposal area does not represent a potential disease reservoir capable of releasing pathogens into the environment. Enteric pathogens have been reported to remain viable for varying, often significant, lengths of time following land disposal of pig effluent (Morse and Duncan 1974; Findlay 1972; Tannock and Smith 1972; Rankin and Taylor 1969; Chandler and Craven 1978b). In general, the survival times were greatest in cool wet soils, less in dry soils or long shaded pasture, and least for short pasture exposed to bright sunlight. Chandler and Craven (1978b) found that following the application of pig effluent, *E. coli* die-out rates in soils were exponential and the time required for a 90% reduction was approximately 14 days.

While few cases of morbidity and fewer cases of chronic disease have been directly associated with the land disposal of effluent, it must be recognised that pig effluent harbours a number of organisms potentially hazardous to human and animal health. Consequently, disposal procedures should take account of this constraint.

Conclusions

M.R. TAVERNER

The increased intensification of production has demanded a more precise control of all factors associated with productive efficiency. Accurate estimates are required of nutritional requirements of pigs at different ages and stages and how these may be met through a diversity of feed sources. In particular, there is a need to utilize by-products of other industries rather than feedstuffs that are also required for human consumption. Grains, for example, are required for human consumption both as a food source and increasingly as an energy source for alcohol production. Furthermore, in confining pigs indoors, it appears that often there has been insufficient regard for their physical and social environment.
This has had serious consequences for pig production manifest in symptoms such as suboptimal reproductive behaviour, piglet mortality and tail biting. It is vital that the environment of the modern piggery is designed to satisfy the behavioural needs of the pig.

A vigorous approach to marketing of pig meats will be necessary if they are to hold or increase their share of the meat market. Foremost in this approach is the rapid adoption of a national carcass classification system.

It seems necessary to recognize that pig effluent is a resource with both energy and fertilizer value. Land disposal is a practical, effective means of reclaiming nutrients from pig effluent. While land application will remain the ultimate means of disposing effluent, more control will be required to comply with the various constraints governing this disposal. Failure to do so may restrict the land disposal of effluent and thereby limit pig production.

The current trend to large scale intensive production units will continue to place the pig industry under increasing pressure due to its heavy reliance on fuel and food energy. Unless new technologies can be developed, it may even be necessary to reverse the trend and move to less intensive systems in order to satisfy issues such as animal welfare, pollution and escalating energy costs.

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