

# Ruminations on future animal agriculture

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## Summary

Major changes world-wide suggest that Australian agriculture has a major economic role to play in supplying food to meet the world's needs. We should anticipate there will shortly be increasing demand for our primary products which will contribute significantly to Australia's wealth.

The reasons for this prediction include:

- World population pressures
- An increasing awareness in the developed world of the pollution of land, air and water, necessitating a down-turn in fuel, fertilizer and chemical use, particularly in Europe and North America
- Increasing demands for changes to improve animal welfare and for reductions in pollution associated with intensive animal production
- Re-emphasis on production from the forage-fed ruminant resulting from a decreasing availability of feed grains
- A widening of pollution awareness to include carbon dioxide and mineral nutrients (fertilizers and manures), and radioactive or chemical residues entering food chains, particularly in Europe and North America, leading these countries to import clean meat

Because of a potential world shortage of grain, increased meat will necessarily be produced by ruminant animals from our cheapest food energy resource which is cellulosic biomass. Australia's ability to meet a demand for 'clean and green' meat with good eating qualities stands out as our strongest advantage and such products will attract premium prices.

Predictable production from grazing animals will be essential. This will require a sustainable land policy, with supplementation of the grazing animal when the vagaries of weather cause a down-turn in production in conjunction with a recognition of the need to destock

land when drought persists to avoid erosion and land degradation. A potential problem is alkaloid-producing endophyte fungi in our pasture grasses.

## Introduction

Since vacating the Chair of Nutritional Biochemistry at this University in 1996, I have had many opportunities to travel both within and outside Australia and to interact with people in rural situations and this has brought home to me the deterioration in living conditions outside the major population areas. I believe that there are, for many reasons, increasing problems of food production in the world, and that there will be a huge problem providing animal protein to meet the global needs of both affluent and poor people.

Enormous pressure has been placed on global land resources to support the burgeoning world population. The rich of the world appreciate 'clean and green' foods and the poor need balanced diets; both cases will benefit from meat in the diet. Economic rationalism has been used to suggest that the meat (protein supply) for the world will come from intensification of animal production, which very often means feeding grain. This brings with it direct and indirect pollution, issues of perceived animal cruelty and reduced employment opportunities, particularly in the developing countries. I am increasingly convinced that there is an increasing need for the 'grass-fed' ruminant as a major source of dietary protein. This, for me, emphasizes Australia as a major world trader in ruminant products and suggests a major re-emergence of ruminant grazing systems as a 'wealth generating' strategy. Australia should be 'gearing up' its infrastructure to support and encourage primary production, particularly meat and grain production.

The need is to refine and emphasize our agricultural and natural resource education at all levels from technical (e.g. 'TAFE') teaching of farmers through to tertiary education if we are to be in a position to take full advantage of our natural advantages in primary production in Australia. I still detect that there is

reluctance to support agriculture. The University of New England is positioned to participate in this exciting future and should emphasize and promote the agricultural and land-based sciences.

## Changes in food production

Australia alone of all the continents has by far the largest relatively undisturbed (in geological terms) land-mass. The mountain ranges appear to have been formed some 80 million years ago and because of the enormous depth of the continental crust, soils have not been replenished by volcanic action or the huge rifts caused by continental drift. In addition, Australia has not experienced general glaciations in the numerous ice ages. As a result, the majority of Australia has soils that are skeletal in nature, heavily leached, and the least fertile of any continent. These infertile soils are rapidly being eroded as agriculture and grazing take their toll.

In his book *The Future Eaters* Flannery (1994) has pointed out that there are only a few areas, particularly in our North Eastern seaboard, where more fertile soil developed, possibly through erosion of volcanic areas, and these support our most intensive crop and animal production. Any strategy that sets out to address efficient long-term animal production in Australia has to recognize the need for more sustainable practices than has occurred in the past, particularly because of the 'old' nature of this land mass.

In most countries, increases in ruminant livestock production have been at the expense of detrimental effects on the soil through overgrazing, or reliance on energy-dense feeds such as cereal grains. This form of production promotes degradation in its widest sense, since land used to produce grain is at greater risk of erosion because of soil disturbance than land under pasture.

The world is already overpopulated, with 800 million people thought to be under threat of starvation. There is little doubt that the predicted large increases in the human population, presently about 6 billion and projected to be close to 9 billion by 2050 (United Nations 1998), will have dire environmental consequences, and will further devalue the quality of life for deprived peoples of the world through slow starvation. The increased food demand will also see depletion of natural marine and land ecosystems.

Over the last 30 years in the developed world there have been great changes in agriculture. Man's ability to exploit land and also marine systems for food production has been forever increasing. In the 1970s considerable concern was voiced by ecologists that the world was about to face mass starvation as we soaked up the energy resources (fossil fuels) and brought more and more land into production to provide food for an increasing population. Land was also brought into production to offset land going out of production through pollution and population pressures requiring land for settlements and interconnecting roads.

Just as world food supplies appeared to be in danger of falling behind population increase, scientific ingenuity found ways to double, triple and quadruple production from the same land areas.

The development of high yielding cereal varieties and the use of chemicals and fertilizers to support their monoculture allowed many of the developing countries to keep pace with demand, and in the industrialized countries allowed increased production of cereals. This was especially dollar-effective as many of these countries were highly mechanised, had large land masses, had access to inexpensive (often subsidized) fertilizers and herbicides and were subsidised by an expanding manufacturing sector. European countries in particular had a 'food security' sensitivity that was a legacy of food scarcities in two world wars.

Over the last 40 years, the material aspirations of people have increased, particularly in the industrialized countries. The increased earning capacity of people was followed by increased demand for 'quality' food and for commodities regarded as luxuries only a few years earlier. An unprecedented requirement for meat and fibre saw Australia at the forefront in producing these in a world where many developing countries barely kept pace with the demand for food, shelter and clothing.

## The impact of surplus world grain

Australian farmers, geared to the export of animal products were able to expand production and Australia has been, and in 1999 continues to be, a major exporter of meat, dairy products and wool. However, improved varieties and management of cereal crops have produced far more grain than the world could adequately distribute. The number of people 'on the bread line', remains high while the preponderance of inexpensive cereal grains has allowed the pig and poultry industries to prosper. Inexpensive grain has also been directly responsible for the development of ruminant feedlotting, predominantly in the USA. This era that has seen the feeding of large amounts of grain directly to animals will be seen in the future as extremely wasteful, as well as costly in terms of soil erosion, fossil fuel consumption at every stage of production—ploughing, planting, herbicides and insecticide manufacture and application, irrigation where it is applied, and storage and transport (see Leng 1995). Though poultry now require about 2 kg of grain, fortified with protein and minerals, to produce 1 kg of liveweight and pigs need 3 kg for 1 kg liveweight, ruminants require 6–12 kg grain per unit of live-weight gain.

The cost of soil erosion should be added to any balance sheet that attempts to record the real economic cost of meat production. The loss of topsoil from cropping lands by all forms of erosion varies from 20 to 40 tonnes per hectare annually, and soil formation is thought to average about 1 tonne/ha annually. Soil erosion rates are highest in the more arid cropping areas. Poorly managed sloping terraces under crops, or

overgrazed and degraded grasslands can lose up to 100 tonnes/ha per year. Well-managed pasture lands, on the other hand, lose annually 7 tonnes of soil per hectare or less, and well-managed forest lands lose negligible soil by erosion (Pimental *et al.* 1995).

The surplus world grain, much of which is being used to feed animals, has been produced at an enormous cost of soil and fossil fuel, and in the near future the production of grain other than for human consumption will need to be restricted.

### World grain supplies and their future utilization

The average annual production of cereal grains in the world is about 2000 million tonnes (USDA 1999) of which about 600 million tonnes (30%) is used in feed concentrates by livestock (Figure 1).

The global use of concentrate feed resources in animal production is shown in Figure 2. If people continue to consume cereals at the same rate, but population increases by 50% by 2050 then the world will need to increase cereal grain production by 700 million tonnes, even if the use of feed for animals remains unchanged. However, as people's incomes and expectations increase, their dietary choices change towards higher intakes of quality cereals and also meat (see Figure 3), so that the need for animal products increases disproportionately as population increases and there are more affluent people in society. The increases in population of people who will increasingly demand animal protein (and ruminant meat) in their diets, are expected to be greatest in Africa and Asia and particularly in China (see Figure 4). Thus, if the present trend continues and more intensification of pig and poultry production also occurs, as it is (Figure 5) in developing countries, then the need for cereals for animal feed will increase faster than that for humans.

This could mean that the projected population growth to 2050 may increase grain requirements for human consumption to 2000 million tonnes and the requirements for grain for animal feed purposes to a similar figure. Unless yields per hectare can be further

increased, the area of cropping land that would be needed for grain production would increase from 1.4 billion hectares to almost 4 billion hectares. An increase of this magnitude for cereal grain production is probably not achievable let alone the massive additional needs for oil crop production.

Over the past 20–30 years low market prices of cereals have given an edge to intensive livestock production. Some estimates of subsidies paid have been greater than 30% of the costs of production in countries such as Europe, Canada and the USA. The impact of many issues is now resulting in a more rational application of subsidies, and import tariffs have been reduced. For example, Canada recently abolished grain freight subsidies; China, however, has attempted to increase grain production by subsidizing grain producers. The anticipated increase in grain requirements by China will dominate the movement of feed grains (Lester–Brown 1994), and China may soak up any world surplus.

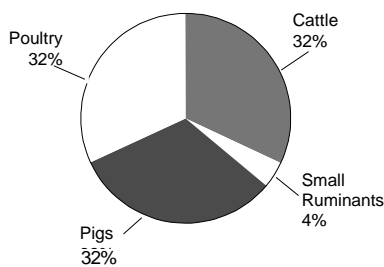


Figure 1 Percentage of feed concentrates used by different classes of animal (after Hendy *et al.* 1995).

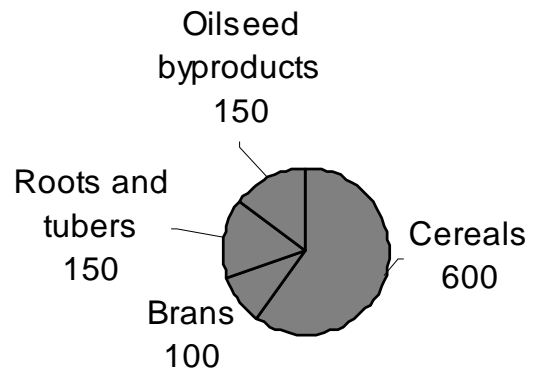


Figure 2 Global use of feeds for animals (in millions of tonnes) (after Hendy *et al.* 1995).

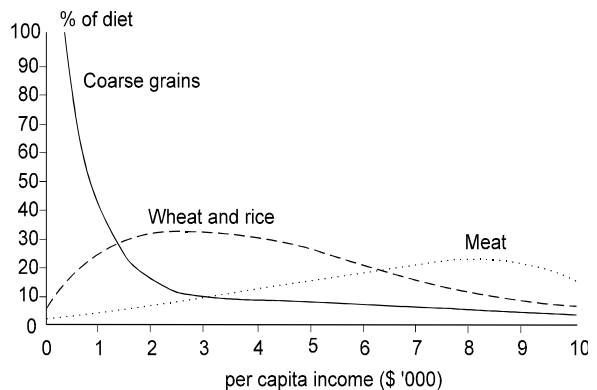


Figure 3 Trends in consumption of meat, wheat and rice and coarse grains against economic status (Marks and Yetley 1987).

Free trade agreements and deregulation of grain prices are expected to lead to a world scarcity of feed grains and generally higher world market prices. Economic policies and subsidies promoting use of cereals for livestock production are to be phased out in the European community and USA. As grain prices rise substantially, a down-turn and eventual cessation of the grain-based ruminant feedlotting systems can be expected as these are the least efficient converters of grain to meat. A much slower decline in the pig and poultry industries should follow.

As ruminant industries return to feeding systems based on forage and crop residue and agro-industrial by-products there will be scope to increase production with modern feeding technologies. Over a much longer time frame, we can expect the pig and then poultry industries to move to a reduced dependency on grain and eventually to move to systems based on sugar from cane, which can produce much greater quantities of energy for smaller inputs of fuel (Preston and Leng 1994).

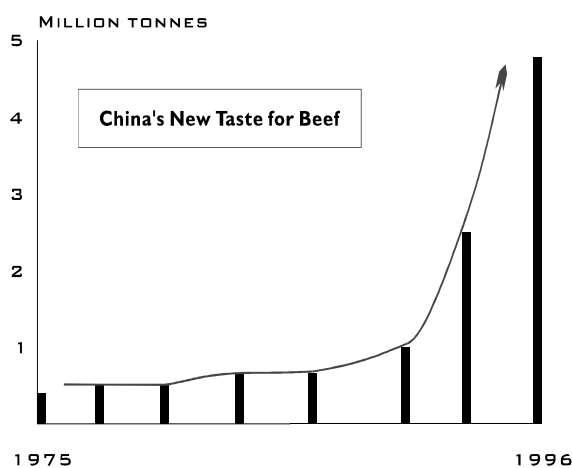
The balance of meats in the market place will also change as the costs of grain in animal feeds increase and are passed to the meat consumer. Meats from grazing animals should be more reasonably priced than those produced in industrial scale systems based on concentrate feeds, particularly where the costs of pollution control are included. If average meat consumption *per capita* doubles, and many non-meat eaters begin to consume meat because they can afford to do so, then the demand for meat protein may increase four-fold.

### Industrial animal production: pollution concerns

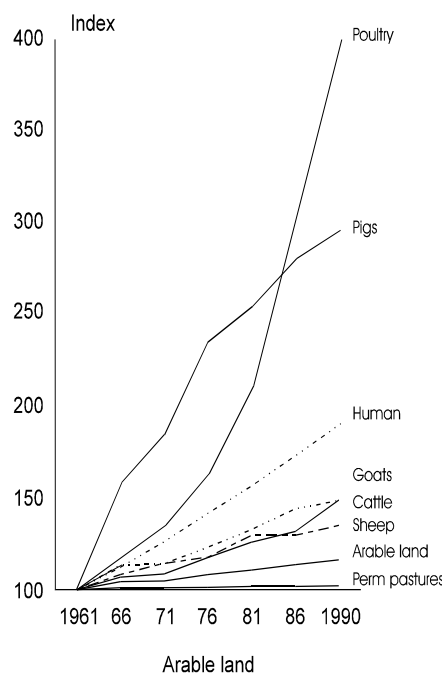
Large intensive animal production systems generate large volumes of wastes, high animal health risks, some risk to humans from zoonoses, as demonstrated by the recent outbreak of Nipah virus in Malaysia, and a need for greater consideration of animal welfare by farmers. Once these enterprises have to absorb the costs of environmental pollution (land, water, air) feedresulting from the accumulation of large amounts of nutrients in one place, they will be less viable (see Leng 1995).

### The potential impact of animal welfare concerns

The growing concerns about the mistreatment of animals under production systems (see Singer 1990), although often misunderstood and misrepresented, will have a powerful effect on the future of industrial scale animal production. The move to free-range pig breeding has already started in Europe, at least partly in response to the revulsion of the largely urban population against 'factory farming'. The recent push by the RSPCA for barn egg production and the dismantling of the intensive egg production systems must lead to more expensive eggs and poultry meats. Animal welfare groups around the world can be expected eventually to focus on closing down ruminant feedlots.



**Figure 4** The increase in consumption of beef in China between 1975 and 1996 (Source: Asian Agribusiness Group 1997).



**Figure 5** Changes in population sizes of farm animals, arable land and farm pastures between 1961 and 1990 (Sansoucy and Aurioi 1986).

## Impact of human population increase

Population is almost static in the developed countries, so the increases will occur mainly in Asia and Africa. Widespread famine from over-population in these regions was predicted in the 1970s by a number of scientists, particularly as the world population headed towards 6 billion. These predictions have been realised in some regions. The most notable famines have occurred in Ethiopia, North Korea and the Sudan, but these have had primarily political causes and famines have not been as widespread as predicted. However, because predictions have only partly become true, people are complacent. Science has been able to increase food production in line with population growth and threats of future famines are seldom taken seriously. World famines have in the main been prevented by greater than anticipated reserves of fuels, the ingenuity of plant geneticists who have been able to improve grain yielding varieties, intensification of fertilizer use, rationalization of land use, and more efficient use of water for irrigation.

Most industrialized countries have subsidized grain production for their own 'food security', whereas the developing countries have struggled to produce sufficient to meet their own requirements. In 1994 the surplus of grain produced largely by industrialised countries was about 120 million tonnes (see Mitchell and Ingco 1994).

## Future increments in grain production

The industrialized countries of the Northern Hemisphere are coming under pressure to reduce their inputs into agriculture in response to the need to reduce environmental pollution. Intensive agriculture in Europe has created water pollution problems by overuse of fertilizers and inappropriate disposal of manure. In Denmark, high nitrate levels in drinking water may even be life threatening and overuse of insecticides and herbicides has contaminated ground water in England to the extent that it is necessary to treat municipal water supplies with ozone before distribution. Mechanization of farming or economic rationalization of agriculture—the 'get big or get out' syndrome—has been instrumental in widescale degradation of habitat for many creatures. In England, the ripping out of hedgerows has led to a massive loss of bird life and animal diversity, arguably made worse by insecticidal and herbicidal poisoning. Public pressure has been such that this is no longer permitted. Europe and the former Soviet block countries have probably done most damage to their environments. The outcome is that, once people become aware of environmental damage, there are strong movements to counteract adverse practices, particularly those associated with export industries.

Irrespective of the country, as people become environmentally aware they will become opposed politically to farming practices that are environmentally unfriendly. They will also oppose industries that they have to subsidise and which lead to surpluses that are then dumped overseas. This must affect particularly those industries involved in producing surplus grain to support environmentally unfriendly animal production systems that are increasingly unwelcome on animal welfare grounds.

There will be support for more sustainable cereal production systems that are at lower risk for the environment but possibly lower yielding.

Asia and South-East Asia are likely to increase grain imports for both human and animal production. It appears that the immediate response of small farmers (the majority of farmers) to the recent economic downturn has been to reduce inputs from off-farm sources. Thus, the use of fertilizer, insecticides, fungicides and herbicides declines, with serious implications for grain production in Asia.

The high yielding varieties of cereals have a narrow gene base and their continued use depends on disease mitigation, ready availability of fertilizers and swift action of plant geneticists to rapidly produce varieties resistant to particularly fungal, but also bacterial and insect parasites, as these organisms become resistant to current control measures. At the extreme, there will be less protection of plants in Asia over the next few years and plant breeders may not make timely introductions of new resistant genotypes.

## Nuclear power and food production

The use of nuclear power for electricity generation also poses problems for future safe food production. This is particularly so in Europe, where there is a huge concentration of nuclear power stations, particularly in France where new stations are still being built (see Figure 6). Contamination of the food chain with radioactive nucleides could be the single most significant catastrophe in Europe, perhaps necessitating the import of food from 'clean' countries such as Australia.

Radioactive contamination from the Chernobyl explosion in 1986 was widespread, affecting food produced in large areas of Europe. The Soviet authorities estimated that between 30 and 50 x 10<sup>6</sup> Curies of radioactive substances escaped. Although this was only a small proportion of the total radioactivity in the core, highly volatile substances such as Iodine-131, Caesium-134 and Caesium-137 escaped, and krypton and xenon gases escaped in their entirety. The radioactive plume reached an altitude of 1500 m and spread over Eastern Europe and Scandinavia causing massive losses in agricultural production estimated in the UK to be \$US15 million, in Sweden \$US145 and in West Germany \$US240 million.

An analysis made shortly after the Chernobyl incident put the potential losses that would have resulted from a similar explosion in a more densely populated country at more than \$US300,000 million. The cost of clearing the debris following the melt down on Three Mile Island was estimated to be \$US1,000 million (Bunyard 1988).

Although the pressure of public opinion has stopped a number of nuclear power stations from being completed in Europe, the number is still high (see Figure 6). More are planned by the newly emerging ex-Soviet Union countries. Although the people of Vienna recently decided in a referendum not to complete a nearly operational reactor in Vienna, a few kilometers across the Danube, Chernobyl-type nuclear reactors are being actively promoted. Two more 'Chernobyl' plants are now planned for Russia. France has insisted that nuclear power is the only means of meeting its energy needs.

The concentration of nuclear power plants is higher in Europe than elsewhere and the chance of a meltdown is therefore higher than in other regions. Because of the likely size of a contaminated area from a meltdown together with the intensive farming systems in Europe, the effects on availability of 'clean' food would be enormous.

The mathematical probability of nuclear reactor accidents has often been calculated as being so low as to be not worthy of serious consideration. In 1957 the US Brookhaven National Laboratory put the probability of the most serious accident occurring in a nuclear power plant at less than one in every million to 1,000 million years of reactor operation. Yet a number of serious accidents have already occurred, viz. at Kyshtym in the USSR (1957), at Windscale in the UK (1957), Three Mile Island in the USA (1979), and in Chernobyl (1986). History contradicts the mathematical predictions and, since Chernobyl, few people accept that nuclear power stations are sufficiently safe to be not worth worrying about.

The editor of *Nature* at the time of Chernobyl wrote: "The important question is not so much how accidents like this can be prevented, but how we can live with them safely". Murphy's law applies: What can go wrong will go wrong.

Part of the issue of living safely with nuclear power stations will be the problem of limiting the radioactive nucleides that enter the food chain. The level of land and food contamination from the events at Chernobyl will never be known. After Chernobyl, the 'acceptable' levels of radioactivity in food had to be raised. Another such disaster could do great damage to the animal industries in Europe and the rich would then prefer to

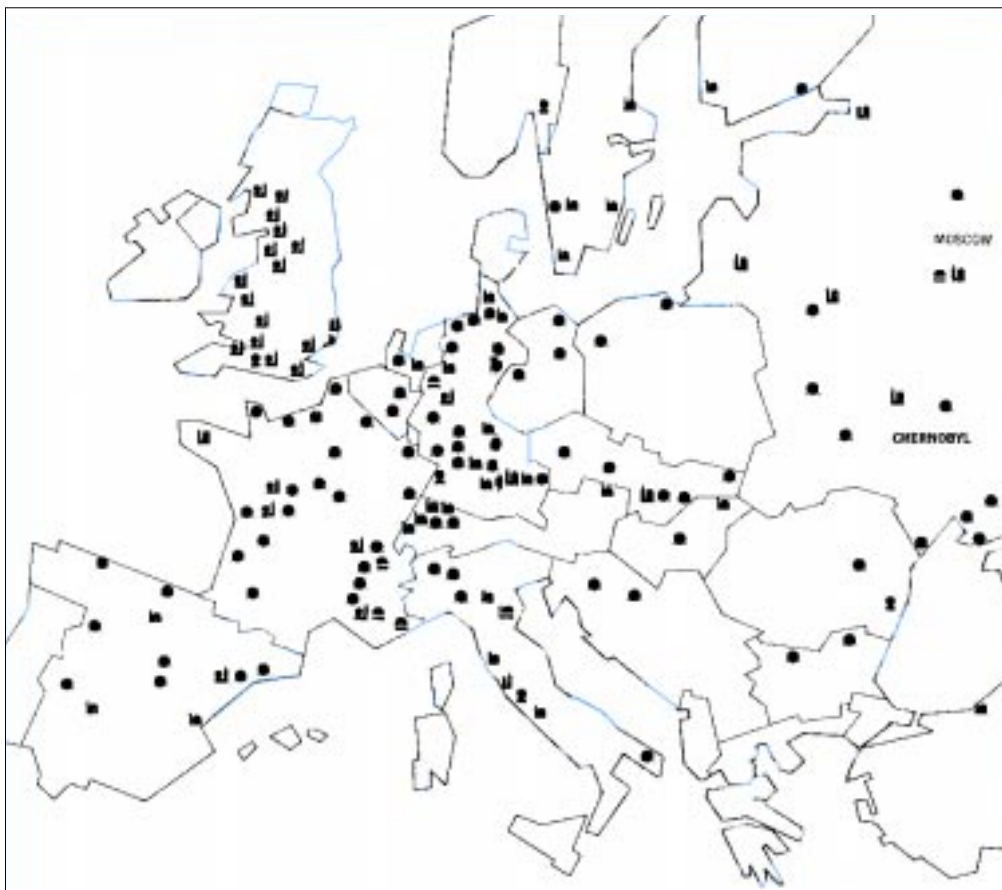


Figure 6 Concentrations of nuclear installations throughout Europe and adjacent countries.

buy animal products from 'clean' areas. Curiously, I cannot find any accounts of contaminated pig and poultry meats; presumably contaminated feeds were avoided by the feed compounding industry which could draw supplies from outside the fall-out areas.

In 1998 (12 years after Chernobyl) inspection of foods entering the UK from continental Europe includes radioactive monitoring, and recently 'radioactive' mushrooms from Poland were rejected. A major nuclear accident in Europe or the USA could lead to serious food shortages in those countries, firstly, because of the reluctance of its population to consume contaminated foods and, secondly because of the reluctance of other countries to import their goods. After Chernobyl there was outrage in both India and Bangladesh when radioactivity was detected in milk and milk powder sent as food aid, even though the levels were insignificant.

What are the chances of a nuclear accident at the level where food production and distribution would be affected? This depends on what you read or where you seek your information. History indicates four major catastrophes have occurred in 30 years. How much radioactivity can be leaked at low levels before food is also contaminated? As with the scare associated with BSE in cattle, it will not take much to generate consumer resistance amongst people of an already alarmed and aware group of nations. Those who can afford to do so, will certainly demand food sources free of contaminants. Australia continues to be able to produce such products (with a few notable problems on the way). World food prices would rise with any new major nuclear leaks in either Europe or America; Australia must be ready for that time.

A lesson from the discussion of nuclear risk is, of course, that Australia should remain essentially 'nuclear-free', even though we can do little to prevent our close neighbours from developing nuclear energy for peaceful (or other) purposes. In addition, we should be alarmed by the public perceptions likely to be created here and overseas by any schemes to provide nuclear waste dumps here in Australia, irrespective of how lucrative these could be.

### Factors that indicate a greater demand for clean export meat

The countries whose exports of surplus grains have kept prices of meat low on world markets (Canada, US, Europe and some Soviet block countries) can be expected to reduce their surplus production in the future for reasons such as:

- Reduced subsidisation of farming
- Reduced yields through erosion and pollution control measures

- Demands backed by 'people power' for a return of agricultural land as 'clean' habitat for birds and animals
- Ever more difficult control of pests
- Reduced fossil fuel availability and government regulation concerning its use
- The almost inevitable contamination of crops and animals by radioactive nucleides when the next nuclear accident occurs (probably in France or in the newly emerging nations that were previously part of Soviet Russia)

In the developing countries the availability of grain for animal production is likely to decline with increasing population density for the above reasons, to which can be added:

- The 'green revolution' may falter through limited use of inputs as economies, and resources such as water, decline
- Increased population pressures directing a greater proportion of the cereal crop to humans
- Increased urbanisation, with a greater share of the reduced yields being retained by small farmers for their own use
- Increased pollution and land degradation
- Global warming posing a special threat to many of the most fertile agricultural lands on river deltas, coastal areas and rift valleys as their climates change, sea levels rise, and crop failures from catastrophic weather takes its toll. A good example of this scenario may be Bangladesh (see Leng 1995)

The net effect of all these changes will be that people 'wake up' to the major problem of the widespread use of natural resources for the inefficient use of grains for animal feed. This is probably the 203<sup>rd</sup> argument against economic rationalism (see Ellis 1999). Unfortunately, many aid authorities consider it impossible to provide extra protein foods in developing countries without feeding grain to pigs and poultry. It was predicted by Lester-Brown (1994) that China alone could import and use the world's surpluses for these purposes in just a few years.

### Grazing versus intensive production systems

Production of meat, milk or fibre from grazing is somewhat fossil-fuel dependent but the implications for fuel resources are not as great as for grain production. For cereal grain production, sustainable, low chemical input systems are needed, with increased production from 'safe areas'. Expansion of grain growing

without safeguards into marginal or semi-arid regions should be denied.

Livestock do not inevitably damage pasture lands, as was evidenced by the great herds of bison and deer that developed in balance with nature in the Americas and Africa. Problems arise with the management (and enclosure) of animals and the lack of flexible strategies to utilise pasture through periods of either high rainfall or drought so that the land does not become destabilised.

About 50% of the usable land surface of the world is utilised by grazing animals. However, grazing systems supply only 9% of the world's beef and 30% of the world's sheep and goat meat. There will be a huge need to increase the efficient utilization of pasture and, at the same time, maintain sustainability. Grazing systems throughout the world occur in arid, semi-arid, sub-humid, humid, temperate and tropical highland zones. Australia encompasses all these zones. The varied nature of such grass and crop lands makes it extremely difficult to rationalise animal production and provide a single simple remedy to low production. Each zone needs different management strategies.

There will be an increasing demand for production of food for export as the pressures discussed above come into play. Australians can only produce a small proportion of the total needs of the importing countries in the world. For example, at the time of writing, China produces and consumes 2.7 times the amount of beef that Australia produces. Even if we increased our food production enormously, we could only make a small contribution to total requirements. A further issue is that the increasing markets will be in Asia where only a small proportion (but still a large number) of people can afford to pay, and in Europe where pollution and economics are important reasons for allowing or denying our products market access.

Australia's likely future markets will be discerning and we should therefore look to quality products, free of any contaminants that could be unacceptable in such markets. In 1999, the USA banned meat products from the EEC when meat from animals given feeds from a single feed manufacturer in Belgium was found to be contaminated with dioxins.

Cattle, sheep and goat production needs to develop to keep pace with demand by more efficient use of the available feed resources; more use of pasture and, in particular of crop residues, considerable proportions of which are still burnt; and improved reproductive performances and enhancement of survival of females and their offspring.

## Droughts and flooding rains

The variable climatic conditions in Australia will require different management approaches in any season or year. However, the scope for increasing productivity from our ruminant systems is great, provided the strategies for higher rates of production when seasons are

favourable are balanced with a thoughtful approach to supplementary feeding which is an integral component of any long term strategy for profitable grazing.

Supplementation should be considered a management strategy that allows the grazier to predetermine the harvest date of his livestock and to ensure efficient reproduction (e.g. a calf every year and survival of both offspring and dam). Some considerations relating to supplementation of ruminants in production systems dependent on tropical and sub-tropical forages or agro-industrial by-products are discussed elsewhere (see Preston and Leng 1987; Hennessy *et al.* 1996; McLennan *et al.* 1995). Appropriate supplementation will optimise microbial digestion of feed and the efficiency of microbial growth in the rumen; when necessary, additional 'bypass' protein will enable the animal to efficiently use the products of fermentative digestion that become available to them from the low-quality forage and thereby increase feed intake.

## Requirements for value-added markets in the future

It has been argued that ruminant meat will become the preferred meat in the future for economic reasons, when costs of pig and poultry rise. The target market is the group of people concerned with quality. Quality meat will contain no residues that are potentially injurious to humans, and it will be tender and palatable which is essentially a 'weight-for-age' criterion that requires cattle to grow at between 600 and 700 g per day from birth to market time

## Contaminants

The maximum allowable concentrations of a wide variety of chemicals in meat that will meet the requirements of an importing country reflect genuine concerns about deleterious effects in people, or may represent an 'import barrier' for some political reason. As the markets increase their vigilance the very extensive monitoring of quality (Egan *et al.* 1998) is likely to increase still further. There may be examination of meat for the presence of toxic compounds produced by plants or forages infected by bacteria, nematodes or endophytic fungi (Edgar 1994).

The alkaloids that are produced by plant endophytes appear to go largely unrecognized in Australia. They pose a conundrum for the main theme of this paper, that the future of the ruminant animal industry resides in production from pasture. Endophytes are well recognized overseas as the cause of fescue toxicity and rye grass staggers in grazing sheep and cattle. However, recent work has focussed attention on endophytes as a cause of less spectacular, but more pernicious low productivity syndromes in ruminants.



The endophyte-induced low productivity losses in cattle on tall fescue pastures in the USA are estimated to be \$600 million annually (see Bacon and Hill 1997). The symptoms described for fescue toxicity in cattle resemble those observed along the whole of the eastern seaboard of Australia on pastures with known problem grasses (i.e. ryegrass and fescue), but also with native pasture species. My observations on a property in northern NSW were that mean daily liveweight gain of cattle was 1.2 kg when grazing pasture where no endophyte association with Parramatta grass (*Sporobolus creber*) was suspected, but the gain was only about 0.5 kg/d when an association was suspected because of symptoms similar to those of fescue toxicity. Endophyte toxicosis may be partly responsible for an 'ill-thrift' syndrome in sheep in northern NSW on native pastures which has been difficult to explain fully. Low productivity in sheep on ryegrass in New Zealand has also been ascribed to endophyte toxicosis, and this condition may, at times, explain 'ill-thrift' that occurs in Southern Australia and Tasmania (Foot *et al.* 1994; Wheatley 1997). Fletcher and Easton (1997), for example, found liveweight gain of lambs was 102 g/d on non-endophyte infected rye grass and only 35 g/d on infected ryegrass. Endophytes are transmitted solely through grass seeds, and some do not reproduce through sporing bodies, so their presence is not necessarily restricted to the plants that have ergots or other fruiting structures (see White 1997). However, in one situation where there was major ill-thrift in cattle, Parramatta grass predominated in the pasture and subsequently produced inflorescences choked by fungal fruiting bodies.

## Endophyte alkaloids and implications for meat exports

The many alkaloid toxins in endophyte infected grasses have been documented by Powell and Petroski (1992). Cattle production losses attributed to endophyte infected tall fescue have been related to ergot-type alkaloids (mainly ergovaline) and possibly to the loline group of compounds. Staggers in sheep and cattle from ingestion of ryegrass are apparently associated with tremorganic alkaloids (lolitrem B) whereas the low production syndrome appears to be caused by other alkaloids produced in the endophyte (Gallagher *et al.* 1987).

Secondary poisoning of humans through ingestion of animal products has been reported (Ames *et al.* 1990a,b) and there is concern that alkaloids and other toxicants produced by plants or plants infected with bacteria or fungi may potentially leave residues in meat (Edgar 1994). Tests to date for alkaloid residues in meat or milk from cattle ingesting tall fescue have not demonstrated any residues; the alkaloids appear to be fully metabolized by animals.

Ruminants are very effective in detoxifying many potentially toxic materials. However, microbial conditions

in the rumen of grazing ruminants are often sub-optimal owing to deficiencies of ammonia or minerals such as sulphur which may compromise detoxification. The growing awareness of the presence of alkaloids in endophyte-infected plants and the relatively unknown situation in Australian pastures in relation to endophyte infection suggest there is a need for more research on this matter in Australia.

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