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An exploration of risk factors for bovine spongiform encephalopathy in ruminant production systems in the tropics

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Summary
The epidemic of bovine spongiform encephalopathy (BSE) in Europe in the late Twentieth Century required the interplay of two sets of factors, which now provide reference points for assessment of the BSE risk throughout the world. One set of factors consisted of the presence of infective agent in cattle or some other ruminant. The second set consisted of transmission and amplification of the disease, made possible through a particular feeding system that allowed persistent and habitual feeding of meat-and-bone meal (MBM) derived from cattle. The authors explore the ruminant production systems of three representative countries in South-East Asia against the background of factors required for the manifestation of BSE. The results can be extended to other countries in sub-tropical and tropical regions where similar, non-industrial ruminant production systems operate. In short, the lack of a nutritionally or economically rational niche for MBM as a source of dietary protein or nitrogen in many ruminant production systems removes the hazard of BSE.

Keywords
Bovine spongiform encephalopathy – Dietary protein – Feeding management – Meat-and-bone meal – Nutrition – Protein nutrition – Plant food materials – Ruminant.

Introduction

Bovine spongiform encephalopathy (BSE) is a superlative example of an emergent zoonotic disease (21). The announcement of BSE in 1986 (40) was accompanied by uncertainty on key unknowns such as the origin, mode of spread, host range and epidemic potential of the disease. These uncertainties diminished as the epidemic unfolded and a systematic programme of epidemiological and experimental investigation clarified the situation. The epidemic and zoonotic potentials are now known. The attack rate of BSE is low and the epidemic is disappearing from cattle. By October 2002, the disease had caused the death of 179,575 cattle at the epicentre in the United Kingdom (UK). Bovine spongiform encephalopathy has led to variant Creutzfeldt-Jakob disease in humans, through the consumption of bovine neural tissue contaminated with the disease agent (30). By December 2002, the disease had caused the death of 119 people in the UK. Figures over the next year or so will demonstrate whether the peak of the epidemic in people has passed.

The comprehensive reviews of BSE (30, 41) and the opinions of the Scientific Steering Committee of the European Commission (8) show that two sets of risk factors must be present concurrently for the disease to appear and become an epidemic. The first set of factors relates to the source of the infective agent and subsequent entry of the agent into the feed supply of cattle. Epidemics of BSE outside the UK originated either in the importation of contaminated meat-and-bone meal (MBM) that was fed to cattle or the importation of infected

cattle that were subsequently rendered and then fed as MBM to other cattle (7). The ultimate origin of the BSE agent that triggered the central epidemic in the UK is uncertain. One suggestion is a sporadic transmissible spongiform encephalopathy (TSE) in an unspecified species of ruminant (30). Another suggestion proposes an origin from scrapie in sheep (4), a disease far more prevalent in the British Isles than anywhere else in the world (6).

The second set of risk factors necessary for an epidemic of BSE relates to features in the animal production system that make possible the transmission and escalation of disease. Ingestion is the sole route of transmission of BSE and the vehicle for transmission has been MBM contaminated with the BSE agent. Accordingly, ruminant feeding systems in which MBM is a nutritionally and economically rational option are essential for the occurrence of BSE. Industrial infrastructures for rendering cattle tissues into MBM, distribution of MBM for feeding to ruminant livestock and subsequent recycling and amplification of the causative agent of BSE are also required for the disease to thrive.

Contaminated MBM was exported to many countries, firstly from the UK and then from other countries in Europe. The fact that BSE has only been observed in countries where the necessary factors for transmission and amplification of the disease operated is no accident. The present paper is based on the notion that ruminant production systems vary according to climate, the presence of specialised industrial infrastructures and the available feed base, particularly the source of protein. As a consequence, some systems, such as those in tropical regions, can be viewed broadly as infertile ground for BSE. The ruminant feeding systems in three countries (Vietnam, Malaysia and Indonesia) are used as illustrative case studies.

Production systems for ruminant livestock in Vietnam

Overview of farming practices in Vietnam

Traditional farming in Vietnam is based on an integrated system of rice, vegetables, root crops, livestock and poultry production. Ruminants such as goats and cattle are used extensively in rural areas (31). However, the system is affected by factors such as a harsh climate, poor soil and a poor water supply that lead to feed shortages and low nutritive value of feed. This, combined with a high disease incidence, increases stress on animals (16, 18), resulting in below-par animal productivity. For instance, Vietnamese Yellow cattle, water buffalo and native goats, which are popular in small enterprises, yield live weights of 250 kg, 320 kg and 22 kg, respectively (11, 39).

Accordingly, the policy of the Government of Vietnam is to change feeding systems from traditional, outdoor husbandry to semi-confinement or confinement in which agricultural by-products can be used as supplementary feeds as much as possible. This type of farming should produce benefits for both the environment and the income of poor farmers.

The role of ruminants is to supply meat, provide draught power for agriculture, supply organic fertiliser and, in the case of poor farmers, to act as a form of savings. Under the present free market economy, the price situation is turbulent and as a consequence, the majority of animal products are consumed domestically and, because of low quality, only a minor part is exported (26).

In short, traditional feeding systems for ruminants are based on local feed resources. Some key issues and solutions for overcoming the constraints in these systems are discussed below.

Traditional ruminant feeding systems in Vietnam

The ruminant production system in Vietnam consists of mixed farming and communal grazing. In this system, communal grazing areas are used as the main source of feed. Crop residues are grazed or, in some cases, used as supplements during night-time confinement (17). Agricultural by-products from rice, cassava, sugar cane, beans, jackfruit, cactus and the like are commonly used as supplementary feeds. This communal grazing system is found throughout the country, but especially in areas with lower human population density, such as mountainous and semi-arid regions. Animals are well cared for, especially females. The principal production objective is reproduction, to obtain additional animals for sale and to increase herd size rather than to increase productivity in meat and/or milk. About 70% of ruminant flocks on middle and large-sized farms are females (15).

Along with increases in the human population and cultivated areas, there is a tendency to increase the number of ruminants on these mixed farming and communal grazing systems, as a means of exploiting communal resources at lower production input. Such systems have clearly increased in number compared with other mixed farming systems based on crop residues, cut-and-carry of forage, or on-farm feed production (2). Livestock farmers and other investors, such as wealthy urban dwellers, are aware that extensive ruminant production (outdoor systems) is more economic than intensive and housed monogastric systems (housed systems) and have been investing more capital in the raising of livestock on communal areas, especially rangelands. Consequently, a positive effect is obtained from mixed farming and communal grazing systems which have the potential for producing more animal products to meet increasing urban demands. However, overgrazing is a risk and could lead to soil erosion and other negative environmental impacts.

Ruminant feed supply in Vietnam

The potential for ruminant production in Vietnam is high with an estimated 2,819,000 buffalo, 3,896,000 cattle, 550,000 goats and 4,000 sheep (3). Most ruminant livestock are raised for meat.

Vietnam has a population of 70,000 dairy cattle. These are located near big cities such as Hanoi or Ho Chi Minh City where the demand for milk is sharply increasing. About 50% to 60% of the feed intake of dairy cows is derived from commercial feed concentrates manufactured from local materials. The rest of the intake consists of grass. The use of concentrates is increasing because pastureland in peri-urban areas is limited and expensive, and concentrates fed at high levels are more economical than pasture grass.

Forage is very important for ruminant nutrition in Vietnam and production potential in terms of available land and climate is high. Vietnam has about 4,000,000 ha of land classified as natural grassland (not fertilised), of which 70% is land with a slope and 30% is steeper. Almost all ruminants in Vietnam are raised on such land and pasture is the main dietary component with average yields of 8 to 10 tonnes of fresh material per hectare. Botanical composition is 2% to 3% native legumes, 50% to 70% grasses, 10% to 20% weeds and 10% to 30% shrubs (27). Livestock productivity in such areas is low. Both the quality and quantity of the feed supply is identified as a major constraint to livestock production and the strategy to improve forage production is to develop cultivars of protein-rich legumes and to devise grazing management systems to optimise animal production. Cultivars nominated include *Leucaena leucocephala* (cultivars Peru and Cunningham) (27), *Stylosanthes guianensis* CIAT 184, *Caliandra calothyrus*, *Gliricidia sepium* and *Flemingia macrophylla* (24) with crude protein contents (on a dry matter basis) of 30.4%, 21.5%, 16.6%, 20.1% and 19.1%, respectively.

Feed materials formulated into diets for ruminants are variable and depend on locally available feed sources, especially agricultural by-products. Feed mixtures are commonly made from rice straw (which is the main feedstuff), rice bran, cassava chips and crop residues such as sugar cane tops, bean leaves and sweet potato. These four ingredients account for 40%, 5%, 5% and 50% of the dry matter in the total diet, respectively (15). Such mixtures are used as supplementary feeds during confinement at night and/or for one or two months for 'finishing' in a so-called immediate feedlot. In most cases, such supplementation significantly increases weight gain up to 20% or 24% compared to no supplementation.

Strategy of the use of local feed resources in Vietnam

Since 1990 and under the Doimoi policy, Vietnam has focused activities on establishing new farming systems in order to fully exploit the potential of tropical ruminant production. The particular aims of the policy are as follows:

– maximise the advantages of tropical agriculture, using solar energy to convert carbon dioxide into biomass and thus obtain a fibre source for ruminant feed through highly productive crops and trees

– develop integrated systems of crops, livestock production and aquaculture in which animals will be synergistic rather than primary producers and where wastes will be recycled to generate fuel and fertiliser to reduce environmental pollution

– identify potential protein-rich feeds from agricultural by-products (e.g. cassava foliage, bean leaf by-products and others) in different ecozones and combine these with leguminous tree cultivation in order to establish appropriate feeding systems that will partially replace expensive commercial feeds and lead to sustainability without necessarily achieving maximum productivity

– promote intake by grazing animals of supplements from agro-by-products by matching their behaviour to locally existing feed resources in order to partially reduce soil erosion caused by overgrazing

– use the livestock production sector as a key tool for reducing poverty in rural areas.

The objectives of the Doimoi policy have met the 'Area Wide Integration of Crop and Livestock' goal of the Food and Agriculture Organization (FAO) in terms of food security and sustainable development. Furthermore, they have encouraged farmers to develop productive mixed farming operations with multi-purpose animals as a mean of 'sustainability' and to increase their income from livestock.

In summary, ruminant production systems in Vietnam are by and large traditional. There is only a small dairy industry around major cities that uses commercially prepared feed and could be classified as industrial. The commercial feeds are based on local ingredients. The great majority of abattoirs in Vietnam are small and the country has no rendering industry and consequently, no domestic production of MBM.

Production systems for ruminant livestock in Malaysia

Agriculture in Malaysia is highly dependent on plantation crops. In addition to being the world top producer of palm oil, the country is also a world exporter of natural rubber and pepper. Livestock production plays a less significant role in the overall national agricultural economy. The gross output value of livestock in 2001 was RM5.8 billion (US$1.53 billion) (1), accounting for about 6% of the total agriculture output (12% of gross national product). Non-ruminant production, such as

pork, poultry and eggs, are competitively efficient and self sufficient, but highly dependent on importation of feed ingredients. However, national demand for beef and milk products far exceeds supply and is therefore highly dependent on importation. Currently, about 78% of the domestic demand for beef, 92% of the demand for mutton and 95% for dairy products are met by imports (statistics of Ministry of Agriculture Malaysia, 2001).

Current ruminant populations consist of 651,000 beef cattle, 26,000 dairy cattle, 85,000 water buffalo, 121,000 sheep and 198,000 goats (1). The population of water buffalo has continued to decline at a rate of 2.5% annually in the last three decades. In contrast, the populations of cattle and small ruminants have remained constant, partly due to the continuous importation of live animals by government agencies and the private sector.

The majority of ruminant livestock belongs to small farmers and grazes along freely roadsides and paddy fields around villages, with very limited supplementation. Feed supplementations, if given, are mainly minerals in the form of common salts. The integration of cattle, buffalo and small ruminants in plantation operations is gaining popularity in Malaysia. In this management system, the animals are allowed to graze the abundant natural grass and shrubs under plantation crops, particularly oil palm and rubber trees. In some cases, small quantities of locally available by-products from the plantations are fed as supplements.

Small-scale feedlots for beef cattle and small ruminants have been in operation in Malaysia over the last three decades. Young feeder animals were mainly imported, principally from Australia, with the remaining animals being provided from local sources. Feedlot animals are mainly fed with local agro-industrial by-products, particularly from the oil palm industry, namely: palm kernel cake, palm oil sludge and oil palm fronds. Pineapple waste from the canneries is another common source of local feed ingredient in beef cattle feedlots. Any supplements used to balance the nutritional requirements of feedlot animals fed the above-mentioned local ingredients, derive mainly from local plant sources. Oil palm kernel cake (14% to 16% crude protein), brewer grains (12% to 14% crude protein) and a limited amount of imported soybean meals (45% to 48% crude protein) are the most common protein supplements used. Animal proteins such as MBM and fish-meals are not used in feedlot rations simply because of economic factors.

Dairying is operated on small-scale family farms located around the main cities. Peri-urban dairy farmers graze their animals around the neighbourhood and supplement them with cut grass and some concentrates. The protein supplements commonly used for dairy cattle are similar to those used for beef cattle, namely: locally available by-products including oil palm kernel and brewer grains in addition to some imported soybean meal and cotton seeds. Locally produced commercial feeds have become available for dairy cattle over the last decade. Meat-and-bone meal is an unlikely ingredient due to the cost of this material. Nevertheless, MBM is sometimes used in calf milk replacers, although whey powder remains the animal protein of choice.

Malaysia imports about 90% of feed ingredients for the local pig and poultry industries. The most commonly imported ingredients are cereal grains, plant and animal proteins, minerals and other feed additives. The traditional sources of MBM have been Australia, the United States of America (USA), Italy and India. Whether Malaysia has imported any MBM from European countries other than Italy in the last two to three decades is difficult to determine. However, it is believed that if any importation occurred, this would have been minimal, again because of price. Following the increased incidence of BSE in Europe, Malaysia imposed an import ban on all MBM, beef and beef products from countries in Europe from early 2001. Currently, the main sources of the 180,000 tons of MBM imported annually are Australia and New Zealand and an equivalent amount of fish-meal is imported from Thailand, Chile and Denmark (32).

Based on the above situations, the concern in Malaysia is not so much the direct use of MBM in ruminant rations, but rather 'cross-contamination' during manufacture of feedstuffs. Due to the limited market for commercially prepared feed for cattle, there is no dedicated feed mill for the production of ruminant feed in Malaysia. Feed mills producing pig or poultry feeds may 'spill' MBM over to ruminant feeds unless thorough flushing of the equipment is conducted prior to converting from production of pig and poultry feeds to ruminant feeds. This represents one of the secondary risk factors for BSE that would only become a real risk if contaminated MBM were present. The risk is over-ridden by the fact that there is no feeding of cattle with cattle tissues in Malaysia.

Production systems for ruminant livestock in Indonesia

Ruminant production in Indonesia

The indigenous breeds of large ruminants in Indonesia include Sumba Ongole cattle, Ongole cross cattle, Bali cattle, Madura cattle, Aceh cattle, Pesisir cattle, Grati cattle, Swamp buffalo, Murrah buffalo, Toraja buffalo and Kalang buffalo. Small ruminants consist of Javanese thin-tailed and fat-tailed sheep, Kacang goats, Etawah cross goats, Gembrong goats and Kosta goats. Djajanegara and Diwyanto (19) have described in detail the distribution of these indigenous Indonesian ruminant livestock in relation to agro-ecological zones. Exotic breeds of cattle include Brahman and Brahman cross, Angus and Angus cross, Simmental and Limousine. Recently some Boer goats

were brought into the country, mostly for research purposes. The population of these exotic breeds are much lower than the indigenous breeds.

Bali cattle are the most predominant of the native cattle and are widely distributed over the country. For example, in the Nusa Tenggara region, one of the most important cattle producing areas in Indonesia, Wirdahayati *et al*. (42) estimated that Bali cattle represent 85% of total cattle populations on the islands of Timor, Flores, Sumbawa and Lombok. Pure breed Ongole cattle are concentrated on the island of Sumba.

Most of the ruminant livestock are raised within the traditional system, characterised by small-scale production (average of two to three animals per farm) and the use of animals as savings. As a consequence, the distribution of livestock in Indonesia tends to follow the distribution of the human population. The island of Java, which represents only 7% of the total land area of the country, is inhabited by more than 60% of the population of Indonesia. Furthermore, 41.7% of cattle and buffalo and 70.2% of sheep and goats are produced on this island (9, 19). In areas outside Java, production systems and scale of production vary according to the agro-ecological zone. In densely populated areas such as Bali and Lombok, ruminants are raised in conjunction with crops. Under this system, the number of livestock owned by a household is very limited, and animals are hand-fed under the cut-and-carry system.

Feeding systems

In the less populated areas of Indonesia, much higher numbers of animals are owned and livestock are mostly tethered during the day and housed at night. In the eastern part of Indonesia, particularly Sulawesi, West Nusa Tenggara and East Nusa Tenggara, free grazing is still possible due to the availability of natural grassland or fallow land. Some areas of Sumbawa Island in West Nusa Tenggara are still available as communal grazing areas for buffalo, cattle and goats. Other parts of the island are dry and only suitable for planting seasonal crops such as soybean, green bean or corn during the rainy season. During the rest of the year, these areas are mostly abandoned and are not suitable for grazing until the following rainy season. Similarly, in some rain-fed rice fields, rice is only planted during the wet season, leaving the area free for animals to graze after harvest.

In East Nusa Tenggara, livestock are generally raised extensively on the available natural grassland. Bamualim estimated that the grazing area in the province that covers the islands of Timor, Flores and Sumba, accounts for 47.3% of the 50,000 km^2 of total land area (10).

The types of feeds offered to ruminants in villages of South Sumatra, West Java and East Java have been studied (9). They have been classified into three major groups: grasses, crop residues and tree legumes. The estimated proportion of grasses in the diets ranged from 42% to 93% while crop residues and tree legumes were 2% to 30% and 1% to 14%, respectively.

In Bali, traditional cattle growers mainly feed their animals native grasses and tree legumes with a small amount of rice bran (25). Surveys conducted in Lombok in West Nusa Tenggara show that native grass is the main component of diets of Bali cattle (29) and Brahman cross cattle (37). Other feeds used in this area are king grass, rice straw, leaves from leguminous trees (*Gliricidia sepium* and *Sesbania grandiflora*), banana leaves, banana trunk and coconut leaves. The feeds offered to goats on this island (13) also comprise fresh forage, predominantly native grasses and *Sesbania grandiflora*.

The dairy industry in Indonesia is concentrated on the island of Java which supports 97% of the 353,000 dairy cattle of the country (figures for 1997) (33). The industry is based on smallholders who typically own three or four cows and are organised into co-operatives. Dairy cattle are usually pure-bred Holstein-Friesian. They are commonly tethered on roadsides where feed is cut and carried to them or they are grazed on crop residues. Milk production is limited by the insufficient use of supplements. Calves are provided with colostrum by suckling for several days, then receive about three litres of milk per day for three months.

Trends in feed utilisation

The importance of native grass

In many parts of Lombok, grass is still considered the best feed for cattle. Even at times when native grasses are scarce, farmers from dry areas prefer to collectively hire a truck and travel long distances to obtain native grasses from wet or irrigated areas, rather than utilising the abundantly available rice straw.

The nutritive value of native grasses in Indonesia is not as poor as often perceived. A feeding study with steers reported that native grass contains 13.95% crude protein and 2.1 Mcal of metabolisable energy per kg (12). In goats with a live weight range of 12 kg to 15 kg, the metabolisable energy intake and microbial protein supply from native grass can be 6.7 MJ per day and 39.6 g per day, respectively (14). A recent unpublished study on Bali calves showed that native grass contains 13.3% crude protein that supplies microbial crude protein at 116 g per kg of dry organic matter intake. The high nutritive value of native grass results from the presence of leguminous species in the grass mixture.

The fact that native grass has high nutritive value and that native grass-fed village cattle are generally in very good condition justifies farmers preferring native grass to other feeds. For grazing livestock, however, caution must be exercised during the dry season because the content of crude protein and some essential minerals declines to below maintenance requirements in most of the natural grasslands of the Nusa Tenggara region (10). As a result, cattle lose up to 25% of body

weight during the dry season. Strategic supplementation must be undertaken to improve cattle productivity. In the Kupang Timur sub-district of East Nusa Tenggara, palm pith (putak), leucaena and sesbania are the main feed supplements for cattle (23). Strategic feeding with mixtures of leaves from leguminous trees (gliricidia, sesbania and leucaena) can improve the bodyweight, milk yield, calf growth and calving intervals of cattle (42).

For housed ruminants, the decline in the availability and quality of native grass is not a major problem because farmers can obtain alternative good quality forages, such as peanut straw derived from large-scale production in irrigation areas. Cattle growers in Java buy peanut straw whereas cattle growers in Lombok obtain peanut straw as a reward for picking peanuts. The nutritive value of peanut haulms and straw has been evaluated as a single feed for buffalo (34). Animals fed peanut straw had a significantly higher feed intake and microbial protein supply compared to those fed king grass and corn stover.

The use of crop residues

The fast growing population in Indonesia has resulted in intensive conversion of agricultural lands for housing, industrial and infrastructure development. As a result, livestock production systems are shifting from extensive to small-scale intensive systems. As the price of land increases, the use of fertile land for livestock production becomes less economical. Consequently, ruminant livestock are produced as a complement to crop production in a crop-livestock system. The carrying capacity is set by the ability of farmers to collect native grasses from rice field bunds or roadsides, which is becoming more difficult. The Government of Indonesia anticipated this change and since the 1980s, has been promoting the use of crop residues such as rice straw as ruminant feed.

Owing to the poor nutritive values and digestibility of most crop residues, feed technologies such as ammoniation and the use of feed supplements have been communicated to farmers through extension exercises and field demonstrations. However, a current study showed that despite intensive promotion of the use of fermented rice straw, none of the respondents applied this feed technology (22). Furthermore, 94% of respondents considered that the feed technology was complicated and time-consuming, while the remaining 6% found it difficult to obtain starter cultures for fermentation. The majority of respondents used native grasses as cattle feed. Farmers realise the importance of using improved grasses as opposed to native grasses, which many believe low in nutritive value. However, due to limited availability of land for planting improved grasses, only 35% of respondents in the study area fed improved grasses to their cattle.

In Bali, the local Government has been promoting the use of a microbe starter (a probiotic with enzymatic action) in feed to improve feeding efficiency in intensive beef cattle production systems. A survey conducted in Bangli Regency (25) showed that 36% of the 50 respondents applied this feed technology, 8% apply a microbe starter with forages while the remaining 24% still use the traditional diet, which is mainly forage (native grass and tree legumes) in addition to a small amount of rice bran. The adoption rate of this feed technology appeared to be positively related to the age and formal education of the farmers as well as to the number of cattle owned. The average cattle ownership in the study area was 7.52 head per farmer (ranging from 1 to 125). Farmers who own more cattle tend to apply intensive systems and readily use the microbe starter-treated complete feed, while those who own less than seven cattle per farm are still reluctant to use this feed technology and rely on traditional feeding methods.

The use of feed supplements

The most common supplement fed to cattle in the traditional system is rice bran. Farmers also use some proprietary concentrate supplements because they realise the advantage of these to improve live weight gain. However, these supplements are considered very expensive and farmers prefer to make their own from a mixture of rice bran, tofu waste, cassava waste or soybean hulls. Few farmers are aware of the importance of mineral and vitamin supplements, and these are used only if provided free by a government institution (22).

A similar situation is observed in the eastern part of Indonesia, especially in areas where high-quality native grasses or tree legumes are readily available. However, there has been a growing interest in the use of urea molasses multi-nutrient block (UMMB) developed by Badan Tenaga Atom Nasional (BATAN), the Atomic Energy Agency of Indonesia. Farmers believe that UMMB improves feed intake and stimulates cattle to eat low-quality roughage. This UMMB, which contains 29% molasses, 18% concentrate, 25% rice bran, 4.25% urea, 7.5% salt, 1.25% mineral mix, 9% calcium oxide and 6% bone meal (imported from the People's Republic of China or the USA), is soft and easily chewable. As a result, cattle will generally consume the daily-recommended allowance of 100 g per 100 kg body weight in less than 30 minutes. However, this soft UMMB will probably not enable maintenance of a constant rumen ammonia level throughout the day, unless the daily allowance is split into several small proportions and fed at different times during the day.

A feed milling industry did not exist in Indonesia until the end of the 1960s. Since that time, this activity has grown rapidly, in line with the expansion of the poultry industry. Figures for commercial feed produced for different animal species in 1997 are shown in Table I (38). The production of commercial feed for cattle has increased markedly since 1997 to cater for a developing feedlot industry based on imported animals, particularly from Australia. Feed for this industry is produced from dedicated plants. Major ingredients used in concentrates for cattle are cassava meal, maize meal, soybean meal, palm kernel, rice bran and various oilseeds.

Table I
Production of commercial feed in Indonesia in 1997 (38)

Consumer	Amount of feed (tonnes)	Proportion of total
Meat chickens	2,153,770	42.6%
Laying hens	2,123,650	42.0%
Pigs	183,540	3.6%
Aquaculture	466,950	9.3%
Cattle	36,250	0.7%
Other species	87,510	1.8%
Total	**5,051,670**	**100.0%**

Concluding remarks for Indonesia

Ruminant livestock production in Indonesia is mainly conducted in traditional systems with small numbers of animals. In these systems, farmers generally feed livestock with fresh forage, such as native grasses and leguminous tree leaves. The animals are also fed a small amount of locally available supplements, such as rice bran, tofu waste and cassava waste. The preference of many farmers for native grass as ruminant feeds can be justified by the generally high nutritive value of these grasses. During the dry season, when fresh forage is scarce, farmers utilise peanut straw, banana leaves and trunk or coconut leaves as alternative feeds. Leguminous tree leaves (sesbania, leucaena and gliricidia), rice bran and palm pith are the most common feed supplements for ruminants in the traditional system.

Due to intensive diversion of land from agriculture to other purposes, the availability of lands for animal production is declining rapidly. Consequently, livestock production is shifting from extensive to small-scale intensive production in the crop-livestock system. In this system, livestock are increasingly dependent on the use of crop residues such as rice straw. However, the abundantly available rice straw is under-utilised by traditional farmers, reluctant to apply feed technology to improve the nutritive value of this feedstuff, as they consider it complicated, impractical and expensive.

Recourse to feed technologies, such as complete feeds and proprietary concentrates, is increasing in dairy production systems and the more intensive and profit-oriented beef cattle production systems. Concentrates are based on least-cost local ingredients such as cassava with maize meal, soybean meal, palm kernel, rice bran and various oilseeds as the source of protein. Indonesia has no rendering plants for the production of MBM and thus, no capacity for the persistent and habitual feeding of cattle with this material derived from cattle.

Conclusions

The BSE epidemic in the UK and subsequent extension of the disease to other countries in continental Europe arose from the coincidence of two necessary sets of factors which serve as the frame of reference for assessing the risk of BSE throughout the world. The first set involved the presence of a TSE in animals, perhaps a sporadic TSE in an unspecified species of ruminant (30) or scrapie in sheep (4). The second set consisted of factors involved in the transmission and amplification of the causative agent of BSE within populations of cattle. The BSE epidemic arose and was driven by the persistent and habitual feeding of rendered tissues in the form of MBM from cattle back to cattle.

Until the advent of BSE, MBM had a role in ruminant nutrition as a source of bypass protein or 'undegradable intake protein' that escapes digestion in the rumen. Bypass protein provides a nutritional benefit in some circumstances such as early lactation, but not in others such as pregnancy or growth. For example, in industrial livestock systems, high-performance dairy cows producing 50 l of milk per day derive a benefit when 35% of their crude protein intake comes from bypass protein (36). As regards MBM, the material is inherently unpalatable for ruminants, varies in organoleptic and nutritional qualities and in South-East Asia, is usually considered too expensive to feed to ruminants (20, 28). In addition, MBM requires considerable care during storage to prevent the development of rancidity, particularly in hot and humid climates. Consequently, MBM has never been a desirable or competitive source of bypass protein for ruminants when other sources were available.

Production systems for ruminants and other livestock are diverse and determined by the various agro-ecological zones in which they operate (35). Systems in which the feeding of MBM to ruminants makes nutritional and economic sense and in which BSE becomes a consideration are the exception rather than the rule on the total world scene. Nevertheless, trade in contaminated MBM and the unreliability of trade figures has placed many countries under suspicion for BSE, regardless of the actualities of animal production practices that will not permit development of the disease. As a consequence, circumstances exist for trading inequities. The FAO responded to the situation by conducting an expert consultation and workshop on protein sources for the animal feed industry in Bangkok in May 2002 (5).

This paper has explored the ruminant production systems of three representative countries in South-East Asia against the background of factors necessary for the manifestation of BSE. The results can be extended to other countries where similar production systems operate. In short, there is no prima facie case for regarding BSE as a possibility. The lack of a nutritionally or economically rational niche for MBM as a source of dietary protein or nitrogen in many ruminant production systems removes the hazard of BSE. Added to this, many countries in South-East Asia do not have a domestic rendering industry and a capacity for producing meat meal from cattle that could drive a home-grown cycle of BSE.

Nevertheless, bans on the importation of MBM from countries with BSE remain the most important line of defence against this disease throughout the world. The fact that ruminant feeding systems, such as those described for representative countries in South-East Asia, exclude the possibility of BSE does not mean that the importation of hazardous MBM should be reconsidered where similar ruminant feeding systems operate. Similarly, countries with BSE should not relax their bans on the exportation of MBM.

At present, MBM provides little or no nutritional or economic benefit for ruminant production in most of the agro-ecological zones of the world and this situation is unlikely to change. Accordingly, claims that excess production of MBM can be diverted to particular geo-economical regions to aid agricultural development and food security should be treated sceptically. The development and application of methods for the complete destruction of BSE infectivity in MBM will not change this situation. At the same time, the diversity of ruminant production systems and their capacity to exclude BSE is a matter for equitable world trade and should be a key consideration in the policies of a country for the importation of safe food.

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Étude des facteurs de risque d'encéphalopathie spongiforme bovine pour les systèmes d'élevage de ruminants en régions tropicales

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Résumé

L'épizootie d'encéphalopathie spongiforme bovine (ESB) qui a frappé l'Europe vers la fin du XX^e^ siècle a résulté de l'interaction de deux groupes de facteurs, qui servent désormais de points de référence pour l'évaluation du risque d'ESB dans le monde. Le premier repose sur la présence de l'agent infectieux chez les bovins ou certains autres ruminants. Le deuxième groupe comprend la transmission et l'amplification de la maladie résultant d'un système particulier d'alimentation des animaux, dans lequel les animaux sont constamment nourris avec des farines de viande et d'os (FVO) provenant de bovins. Les auteurs étudient les systèmes d'élevage bovin dans trois pays représentatifs de l'Asie du Sud-Est en examinant les facteurs nécessaires à une manifestation de l'ESB. Les résultats sont extrapolables à d'autres pays des régions subtropicales et tropicales disposant de systèmes non industriels d'élevage de ruminants présentant des caractéristiques analogues. En résumé, l'absence de risque d'ESB dans de nombreux systèmes d'élevage de ruminants s'explique par l'absence de débouchés économiques et de besoins nutritionnels qui justifieraient le recours aux FVO comme source de protéines ou d'azote alimentaire.

Mots-clés

Aliment d'origine végétale – Encéphalopathie spongiforme bovine – Farine de viande et d'os – Gestion de l'alimentation des animaux – Nutrition – Nutrition protéique – Protéine alimentaire – Ruminant.

■

Estudio de los factores de riesgo de encefalopatía espongiforme bovina en los sistemas de producción de rumiantes de los trópicos

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Resumen

La epizootia de encefalopatía espongiforme bovina (EEB) que se declaró en Europa a finales del siglo XX vino determinada por la conjunción de dos grandes grupos de factores, que ofrecen hoy en día elementos de referencia para evaluar el riesgo de EEB. El primer conjunto de factores fue la presencia del agente infeccioso en el ganado bovino u otros rumiantes, y el segundo la transmisión y amplificación de la enfermedad en virtud de un sistema particular de alimentación que propició la ingesta repetida y frecuente de harinas de carne y huesos de origen bovino. Los autores examinan los sistemas de producción de rumiantes de tres países representativos del Sureste asiático a la luz de los factores necesarios para que se manifieste la EEB. Sus resultados pueden hacerse extensivos a otros países de regiones tropicales o subtropicales en los que funcionan sistemas similares de producción pecuaria artesanal. En pocas palabras, no existe peligro de EEB porque no hay razón alguna, ya sea alimentaria o económica, que induzca a utilizar harinas de carne y huesos como fuente de proteínas o de nitrógeno alimentario.

Palabras clave

Aporte de proteínas – Encefalopatía espongiforme bovina – Gestión de la alimentación animal – Harina de carne y huesos – Nutrición – Producto alimentario vegetal – Proteína alimentaria – Rumiante.

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