DEVELOPMENT STRATEGIES FOR GENETIC EVALUATION FOR BEEF PRODUCTION IN DEVELOPING COUNTRIES

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Development Strategies for Genetic Evaluation for Beef Production in Developing Countries

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Editors: Jack Allen and Ancharlie Na-Chiangmai

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Preface

The Department of Livestock Development (DLD) in Thailand has a high priority for research into genetic improvement of beef cattle and swamp buffalo. A national breeding program has been established for decades to help increase meat production. Initially, selection for increased growth rate was carried out on the basis of a central performance test. Growth and fertility traits have been recorded on paper from DLD research stations for more than 20 years.

In 1993, the Australian Centre for International Agricultural Research (ACIAR) funded a project (AS1/1993/011) for the DLD, in conjunction with the Agricultural Business Research Institute (ABRI), to establish a database system for genetic evaluation and improvement of beef cattle and buffalo in Thailand. The computerised data were then analysed using GROUP BREEDPLAN—a pedigree/performance recording and analysis system developed in Australia by ABRI and the Animal Genetics and Breeding Unit (AGBU). The estimated breeding values (EBVs) for individual animals are obtained using a multi-trait animal model in a Best Linear Unbiased Prediction (BLUP) method for across-herd evaluation. The influence of management, environmental effects and non-genetic effects are taken into account.

The initial focus of the ACIAR project was the genetic improvement of Thailand's beef cattle and buffalo herds through the use of government breeding programs using BREEDPLAN EBVs to select superior breeding animals. The DLD then used various programs to get these superior animals into village production systems.

The system has now been expanded by the DLD to include data on livestock recorded in the villages. This will assist government farms in producing good genetic parent stock that perform well under village conditions. As well as improving the genetic potential of the livestock, the scheme will also be used to train villagers in breed improvement and explain EBVs as one of the tools for this. Hence, it is expected that EBVs will become more widely understood and be used in the trading of breeding animals.

The use of villages in the breeding program will also lead to in situ genetic conservation of the native cattle where low inputs combined with sustainable production systems will help meet local beef consumption demands.

This workshop was organised so that Thailand could share its experiences and results with other Southeast Asian countries who share similar production environments and constraints with the aim of sharing information and ideas and to foster cooperation in Southeast Asia for beef production and breeding.

This workshop would not have been possible without significant cooperation and support from ACIAR, DLD, ABRI and the participating country representatives. The organisers would specifically like to acknowledge:

- The Australian Centre for International Agricultural Research (ACIAR) for its significant funding support, and
- Dr Rapeepong Vondee, Director General, DLD and the numerous DLD staff who made significant contributions to the ACIAR project and this workshop.

Recommendations from the workshop were developed from active participation of the delegates in the working groups. This input was significant given that the 13 attending countries represented more than 3.1 billion people, 382 million beef cattle and 152 million buffalo. These recommendations are aimed at furthering cooperation within Southeast Asia for animal breeding programs—not only at the researcher level but also at the various levels of government that have important impacts within and between country policies.

Ancharlie Na-Chiangmai, Chief of Buffalo Research Group, DLD
Jack Allen, Technical Director, ABRI

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Recommendations

International Workshop on Development Strategies for Genetic Evaluation for Beef Production in Developing Countries

Recommendations

ANIMAL recording systems are necessary. They are required for animal breeding programs as well as for monitoring and management of other programs and initiatives. Permanent, unambiguous and unique identification of animals (particularly beef cattle and buffalo) needs to be a primary consideration with this identification being compatible with computer orientated recording systems. Simple but effective national identification systems should be implemented in preference to localised ones—particularly for those animals involved in breed improvement programs. Measurement techniques and trait definitions should be standardised across and within countries where common traits are being recorded. In this respect, the International Committee for Animal Recording (ICAR) should be a useful contributor.

National breeding and management programs, with a strong focus at the village production level, should be given strong consideration. These programs need well-defined objectives with long-term commitment from Government to ensure their success. Government policy decisions and funding should be viewed in respect of these commitments. In this context, a review of the present systems and strategies is considered highly desirable, followed by ongoing monitoring of initiatives to ensure that the changes being implemented are in fact benefits and are sustainable within the production and marketing systems.

Emphasis in breeding programs should be to improve local strains using all relevant techniques and to evaluate and optimise gene flow principles to disseminate the improved genetics through the targeted industry. Cross-breeding strategies, particularly where exotic breeds are shown to be of real value, should be developed.

Production systems, by necessity, will vary by region, climate, market and social preference. While national support and monitoring is very important, production systems need to be developed with a regional focus. Long-term breeding objectives need to be developed for the local production systems and the major market requirements. These need to be supported and encouraged through the use of producer focused extension techniques, such as field days and demonstration sites/villages focused on specific target groups. The aim of this extension should be to assist the producers at the village level to be more productive and profitable and to sustain long-term production without ongoing external support from Government or aid agencies.

Cooperation across disciplines, within and between countries and across agencies, is extremely important to develop sustainable and effective production systems. All groups are encouraged to participate in cooperative schemes and discussions as few systems can be developed and become sustainable without a multi-discipline approach. Cooperation is required at Government level regarding international and national policies and committees.

The FAO initiated Animal Production and Health Commission for Asia and the Pacific (APHCA) should implement regionally focused animal breeding programs with a focus on across country cooperation and development to maximise the results at the village level from the limited resources available. Long term strategies and policies towards breeding should be developed and encouraged. There is a strong requirement for the coordinated training of professionals throughout the region where sharing of expertise from developing countries is emphasised.

The International Livestock Recording Institute (ILRI), FAO and ICAR should encourage regional cooperation towards animal recording and trait development aimed at Southeast Asia. Cooperation should extend across countries while encouraging focused meetings on regional issues of importance. ILRI should initiate and link databases of research results and findings that are available in electronic format (e.g. web-based strategies) so that researchers and aid organisations have access to the latest developments within a reasonable time frame. This electronic system should also be used for day-to-day communications and group discussion-based problem solving.

Cooperation at the scientific and research level should be encouraged through conferences and linked information web sites. The Asian-Australasian

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Association of Animal Production Societies (AAAP) should be encouraged to have active meetings within and between countries to promote regional discussions to share problems, ideas and research results. These should focus on both research and applied breeding programs. As part of these meetings, specific sessions should address implementing and monitoring production systems at the village level. Funding of participants who are actively working at the village level is encouraged and international aid agencies, such as ACIAR and JICA, should consider this of high importance.

Country Papers

Country Report: Australia

Jack Allen[1]

Abstract

BEEF cattle are produced across Australia on properties with a diversity of enterprises. Specialists beef properties carry around 58% of Australia's beef cattle and non-beef specialists carry around 28%. As a general rule, about 20% of Australia's larger beef enterprises account for nearly 80% of the beef cattle population. Genetic evaluation of Australian cattle is done via the BREEDPLAN evaluation system marketed by the Agricultural Business Research Institute. Twenty breed societies have genetic evaluations run off their databases. In some breeds, pedigree and performance details have been collected for more than 30 years. Approximately 100,000 calves per year are being added to these databases where BREEDPLAN calculates Estimated Breeding Values for up 17 performance traits.

AUSTRALIA is an island continent and is the sixth largest country in the World. It has a population of 19 million people and a land area of 7 692 030 square kilometres (Table 1) which is more than 5% of the World's total land mass. Australia features a wide range of climatic zones, from the tropical regions of the north, through the arid expanses of the interior, to the temperate regions of the south.

Widely known as 'The Dry Continent', the land mass is relatively arid, with 80% having a median rainfall less than 600 mm per year and 50% less than 300 mm (the average is 450 mm). Seasonal fluctuations can be large, with temperatures ranging from above 50 °C to well below zero. However, extreme minimum temperatures are not as low as those recorded in other continents.

Australia experiences many of nature's more extreme phenomena, particularly droughts, floods, tropical cyclones, severe storms and bushfires.

Australia is a relatively flat continent, with mean elevation just exceeding 200 metres. The dominant feature of the continent is the Great Dividing Range which spans the length of the Eastern Seaboard. There are very few naturally good soils for agriculture. Most are infertile and shallow, with deficiencies in phosphorus or nitrogen. To offset these deficiencies, superphosphate and nitrogenous fertilisers are widely used, particularly on pasture and cereal crops. Fragile soil structure and a susceptibility to waterlogging are other common features of Australian soils, while large areas are naturally affected by salt or acidity. These soil characteristics restrict particular agricultural activities or rule out agricultural activity altogether.

With the exception of Antarctica, Australia is the world's driest continent. The wet northern summer is suited to beef cattle grazing inland and the growing of sugar and tropical fruits in coastal areas. The drier summer conditions of southern Australia favour wheat and other dryland cereal farming, sheep grazing and dairy cattle (in the higher rainfall areas) as well as beef cattle. Within regions there is also a high degree of rainfall variability from year to year, which is most pronounced in the arid and semi-arid regions. Rainfall variability often results in lengthy periods without rain. The seasonality and variability of rainfall in Australia require that water be stored, and 70% of stored water use (including ground water) is accounted for by the agricultural sector. Storage tries to ensure that there are adequate supplies all year round for those agricultural activities requiring a continuous supply. Irrigation has opened up areas of Australia to agricultural activities which otherwise would not have been suitable.

Evaporation is another important element of Australia's environment affecting agricultural production. Hot summers are accompanied by an abundance of sunlight and high rates of evaporation.

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Since European settlement, the vegetation of Australia has altered significantly. In particular, large areas of Australia's forest and woodland vegetation systems have been cleared, predominantly for agricultural activity. The areas that have been altered most are those which have been opened up to cultivation or intensive grazing. Other areas, particularly in the semi-arid regions where extensive grazing of native grasses occurs, now show signs of returning to timber and scrub.

In spite of Australia's harsh environment, agriculture is the most extensive form of land use. At March 1999, the estimated total area of agricultural establishments in Australia was 453.7 million hectares, representing about 59% of the total land area. The rest of the Australian land area consists of unoccupied land (mainly desert in western and central Australia), Aboriginal land reserves (mainly located in the Northern Territory), forests, mining leases, national parks and urban areas.

Livestock grazing accounts for the largest area of land use in Australian agriculture. This activity has led to the replacement of large areas of native vegetation by introduced pastures and grasses in the higher rainfall and irrigated areas.

At March 1999, 5% of Australia's agricultural land was under crops, with a further 5% under sown pastures and grasses. This maintains a trend which has seen about 10% of Australia's agricultural land under cultivation each year since the 1980s. Until this time, the area of land cropped or sown to pastures and grasses had been expanding rapidly. This expansion was facilitated by factors including increased use of fertilisers, improved water supply and reduction in the rabbit population due to myxomatosis.

A broad statistical profile of Australia and Australian agriculture is presented in Table 1. The value of aggregate annual turnover attributed to agricultural industries is estimated to be nearly AUD$28 billion in 1998–99 (Figure 1). The apparent per capita consumption of various agricultural products is listed in Table 2 while Figure 2 shows the trends in consumption for various meat types.

Cattle Population

Basic statistics

Australia had no cattle or buffalo prior to European settlement in the 1800s. Since then, cattle numbers have steadily increased to peak at 33.4 million in 1976 reducing to the current level of around 26.6 million (Table 3). However, Australian livestock numbers in general have considerable fluctuations due to wide climatic variations across years.

Dairy cattle are generally restricted to the southern, coastal districts of Victoria, New South Wales, South Australia and Western Australia. However, beef cattle are reared in most areas of Australia with a concentration in Queensland and New South Wales (Figure 3 and Table 4).

Table 1. General statistics on Australia.

Description	Australia	World
Total human population	19.3 million	6002.5 M
Annual growth	1.3%	1.3%
Land area	7,692,030 km^2	135,774,000 km^2
(39% tropical, 61% temperate)		
Agricultural land use:	59% of total land	
— Crops	23.3 M ha. (5.1%)	
— Pasture	22.5 M ha (5.0%)	
— Other	407.9 M ha (89.9%)	
Employment in Agriculture (1999) was 2.1% of total population:		
Males	278,700	
Females	129,100	
Gross value of commodoties (1998–1999):		
Crops	AU$16,171 M	
Livestock — Slaughter	AU$7401 M	
Livestock — Products	AU$5418 M	
Establishments with Agricultural Activity (1999):		
— Total	145,226	
— Grain+sheep+beef	18,954	
— Sheep+beef	8674	
— Beef	33,163	
— Dairy	13,963	
— Poultry (meat)	773	
— Poultry (eggs)	579	
— Pigs	1129	

Source: Australian Bureau of Statistics.

Figure 1. Aggregate turnover (AU$ billion) per year of Agricutural Industries. *Source: Australian Bureau of Statistics.*

Table 2. Apparent per capita consumption of selected agricultural products.

Product	1998–99	1988–89
Beef	34.9 kg	38.3 kg
Veal	1.5 kg	1.7 kg
Lamb and mutton	16.3 kg	22.1 kg
Pig meat	19.0 kg	17.5 kg
Bacon and Ham	8.7 kg	6.9 kg
Poultry	30.8 kg	24.1 kg
Milk	102.4 l	101.7 l
Cheese	10.7 kg	8.8 kg
Butter	2.9 kg	3.2 kg
Margarine	12.8 kg	18.0 kg

Table 3. Livestock numbers by year.

Year	Cattle ('000)	Sheep and Lambs ('000)	Pigs ('000)
1931	11,721	110,568	1072
1941	13,256	122,694	1797
1951	15,229	115,596	1134
1961	17,332	152,579	1615
1971	24,373	177,792	2590
1981	25,168	134,407	2430
1991	23,662	163,238	2531
1999	26,578	115,456	2626

Source: Australian Bureau of Statistics

Total beef production in 1999 was 2 million tonnes carcass weight with nearly half being produced in Queensland (Figure 4). Australia exports 66% of its beef production (Figure 5) and is the largest exporter of beef in the world (Figure 6).

Table 4. Cattle by age, sex, purpose and State.

	1994 ('000)	1999 ('000)
Milk cattle:		
— Cows (includes dry)	1786	2155
— Other	892	1065
— Total	2678	3220
Meat cattle:		
— Bulls (mating)	557	528
— Cows and Heifers	12,076	11,621
— Calves under 1 year	5388	5740
— Other Cattle (> 1 year)	5058	5469
— Total	23,080	23,358
Cattle by State:		
— New South Wales	6515	6291
— Victoria	4189	4125
— Queensland	9942	10,748
— South Australia	1202	1183
— Western Australia	1806	1931
— Tasmania	679	724
— Northern Territory	1435	1567

Source: Australian Bureau of Statistics.

The live cattle export trade provides a particularly important outlet for cattle producers in Northern Australia. Southeast Asia is the main market (Figure 7) as transport distances are relatively short and the *Bos indicus* derived breeds cope well with the tropical conditions during transport and upon arrival. The cattle are generally put into feedlots and slaughtered when finished. Australia's disease-free status is also extremely important in maintaining these important markets.

Beef cattle are produced across Australia on properties with a diversity of enterprises. Of the 71,600 individual farms represented in the 1998–99

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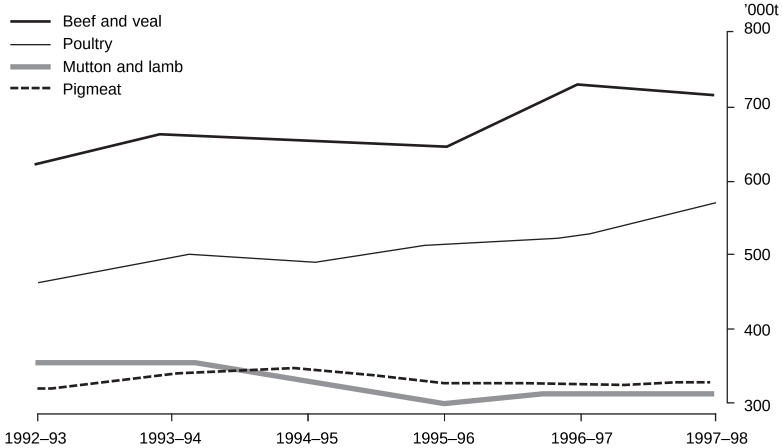


Figure 2. Meat consumption trends ('000 tonnes) by meat type.
Source: Meat and Livestock Australia

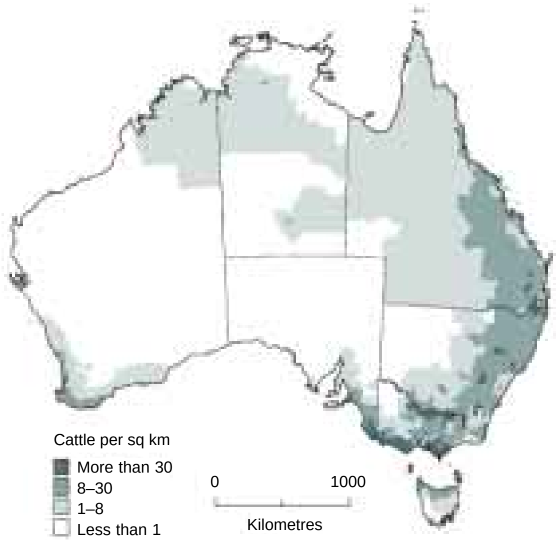
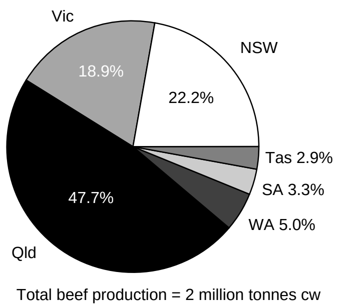
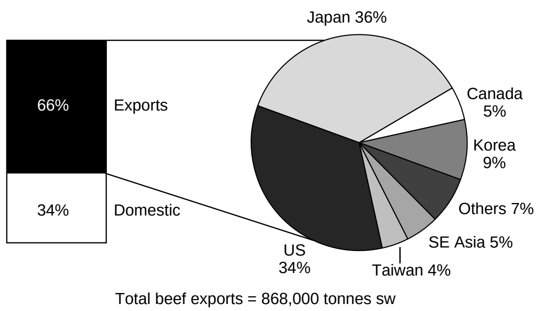


Figure 3. Distribution of cattle in Australia.
Source: Meat and Livestock Australia



Source: ABS

Figure 4. Australian beef production 1999.



Source: ABS/AFFA

Figure 5. Beef production and exports — 1999.

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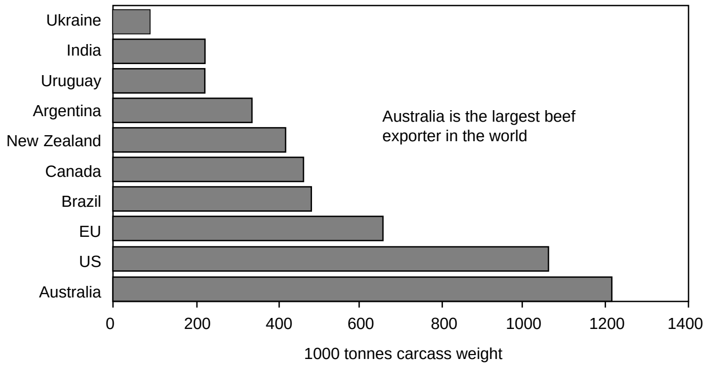
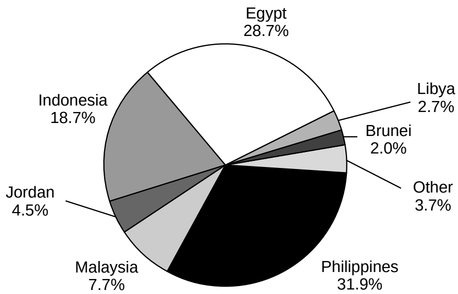


Source: USDA

Figure 6. Top ten world beef exporters 1999.



Source: ABS/AFFA

Total live cattle exports = 841.372 head

Figure 7. Australian live cattle exports 1999.

Australian agricultural and grazing industries survey conducted by ABARE, an estimated 17,700 properties were engaged mainly in running beef cattle (beef specialists). A further 22,800 properties ran more than 50 beef cattle but were mainly engaged in enterprises other than beef cattle (non-specialist beef properties). Specialist beef properties carry around 58% of Australia's beef cattle and non beef specialists carry around 28%. Most cattle are grassfed but grainfed cattle account for 17% of turnoff or 20% of beef production.

The average herd size of beef specialist properties is 765 head, although nearly half of these properties carry fewer than 300 head (Figure 8). As a general rule, about 20% of Australia's larger beef enterprises account for nearly 80% of the beef cattle population. In 1998–99, approximately a third of specialist beef properties were located in Queensland, followed by 29% in NSW and 23% in Victoria.

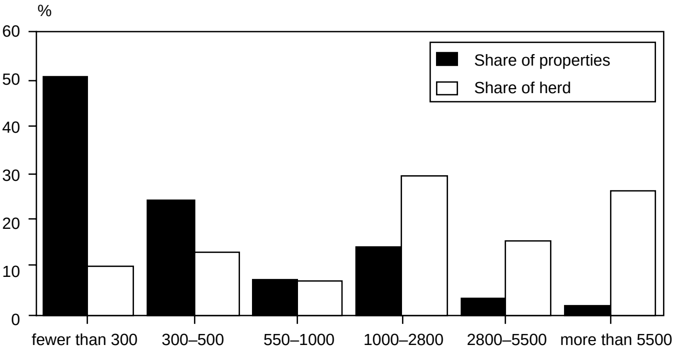
The Australian beef industry contributes an estimated AUD$4–5 billion to incomes in rural Australia. More than 17% of Australian farm production value and 14% of rural export earnings are directly attributable to the beef industry.

Statistics on the breed composition of Australian beef cattle have not been collected to any large degree. However, within Northern Australia where beef production is predominantly tropical, there is a predominance of indicus-derived animals (Table 5).

Table 5. Estimated beef herd composition in Northern Australia.

Breed type	Percentage
Brahman	25.0%
Indicus/Taurus cross	38.4%
Other tropical	10.2%
British and European	16.1%
Santa Gertrudis	6.2%
Other	3.6%

Source: ABARE Australian Farm Survey — 2000
Northern includes Queensland, Northern Territory and the Pilbara and Kimberley areas of Western Australia



Source: ABARE

Figure 8. Distribution of specialist beef properties by herd size 1998–99.

The Australian seedstock sector has undergone radical redistribution of breed types over the past 10 years (Table 6). As well as total registrations declining by about 25%, the relative significance of European breeds declined dramatically to about 50% although Charolais maintained its registration level albeit from a small base. Interestingly, the only British breed recording large numbers of calves to go against this trend was Angus which is perceived to be a good type for marbling and is favoured for the Japanese market.

Productivity information

Australian beef production is broadly categorised into the northern (tropical) and southern (temperate) Australian industries. Productivity varies considerably within and between categories and also by breed type and general management. Table 7 broadly outlines various productivity markers.

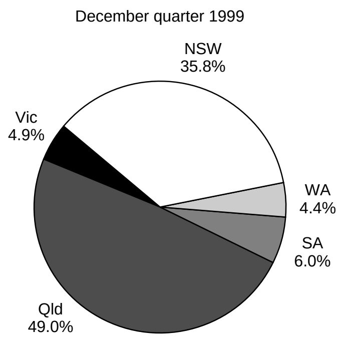
Markets are quite diverse but often overlap in their requirements (Table 8).

Feedlots have grown in importance in Australia since 1991 when the Japanese grainfed market became available to Australian beef. There are over 850 feedlots accredited to operate in Australia, accounting for 17% of beef turnoff or about 20% of beef production. In 1999, there were 518,144 animals finished in feedlots prior to slaughter (Figure 9).

The major grainfed cattle specifications are:
- Japanese lotfed fullset market over 360 days on feed — Japanese steers;
- Japanese shortfed fullset market 120 days on feed — Japanese steers;
- Japanese medium fed fullset market 180 days on feed — Japanese steers;
- Domestic supermarket/butcher market 70 days on feed — young cattle.

Profitability in the Australian feedlot industry is determined by:
- Grainfed fullset export prices to Japan;
- Australian domestic grainfed beef demand and prices;
- Grain and other feed component prices;
- Feeder cattle cost.

The most common method of selling beef cattle in Australia (Figure 10) is through the auction system (41% of cattle are sold through this method). The traditional strengths of auction saleyards include the fact that buyers can see the animals they are paying for; and the competitive nature of the pricing.



Source: ALFA/MLA Total = 518.144 head

Figure 9. Australian cattle on feed (1999).

The other major method of selling cattle in Australia is called Over-the-Hooks (OTH). Under this system prices are negotiated directly with processors and 32% of cattle are now sold this way. Cattle are generally sold on a dollar per head or cents per kilogram liveweight basis.

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Table 6. Australian beef cattle registrations by breed.

British breeds and Australian derivatives	1990	1995	2000
Angus	13,280	16,623	22,611
Poll Hereford	33,763	26,941	20,277
Hereford	32,764	24,067	17,637
Murray Grey	11,072	11,680	8761
Shorthorn	8119	6350	6718
South Devon	1863	1266	1635
Red Angus	285	1755	1575
Red Poll	2077	908	788
Devon	2190	1242	710
Australian Lowline	n.a.	n.a.	461
Beef Shorthorn	714	451	299
Galloway	559	328	179
British White	n.a.	n.a.	93
Group total	***106,686***	***91,611***	***81,744***
Tropical breeds			
Brahman	18,496	13,427	11,932
Santa Gertrudis	9477	8180	8312
Droughtmaster	4044	6007	6793
Brangus	1068	1432	1842
Braford	4176	2263	1518
Belmont Red	1033	704	1476
Charbray	493	245	350
Tuli	–	60	161
Boran	–	41	26
Sahiwal	299	158	na
Greyman	–	71	na
Group total	***39,086***	***32,588***	***32,410***
European breeds and derivatives			
Limousin	9403	10,407	4479
Charolais	3939	4152	4055
Simmental	13,669	7823	3861
Gelbvieh	187	1044	1023
Romagnola	562	977	573
Blonde d'Aquitaine	599	1055	457
Salers	1637	870	363
Maine Anjou	503	561	134
Aust. Braunvieh Assoc.	n.a.	n.a.	127
Piedmontese	–	161	80
Belgian Blue	n.a.	198	47
Chiangus	103	21	36
Chianina	168	113	34
Original Braunvieh	200	121	na
Group total	***30,970***	***27,503***	***15,269***
Other			
Wagyu	n.a.	300	1260
Mandalong Specials	n.a.	388	86
Grand total	**176,742**	**152,390**	**130,769**

Compiled by: Australian Registered Cattle Breeders' Association Inc.

Saleyards are becoming less important components of the meat and livestock chain. The chief reason is the drive to limit stress on animals by cutting down the periods of transition and exposure to new and novel situations evident during transportation, holding and in saleyards.

Direct methods of sale such as OTH selling can provide producers with more information on the carcass quality of cattle they produce and reduce carcass damage caused by additional handling required for saleyard auction sales.

Genetics and breeding programs

Genetic evaluation of Australian cattle is done via the BREEDPLAN evaluation system marketed by the Agricultural Business Research Institute. This system will be discussed during the workshop.

Table 7. Indicative productivity markers in the Australian beef industry.

Productivity marker	Northern	Southern
Industry		
Use of AI — seedstock (%)	15	20
Use of AI — commercial (%)	5	10
Use of ET — seedstock (%)	2	5
Cows		
Age at first calving (years)	3.5	2.5
Inter-calving Interval (days)	450	390
Years cow used in herd (years)	5	5
Average conception — natural (%)	65	90
Average conception — AI (%)	50	85
Bulls		
Mating load (cows per bull)	30	20
Years bulls used in herd (years)	2.5	2
Calves		
Age at weaning (days)	180	220
Daily gain to weaning (kg/day)	0.8	1.1
Age at slaughter (years)	2.5	1.7
Live weight at slaughter (kg)	400	400

Notes: The numbers presented in this table are purely indicative to get some broad concept based on the editors experience of the likely values of the indicators. The actual values vary enormously within and between markets, breeds, regions and tropical/temperate areas.

Twenty Breed Societies have genetic evaluations run off their databases. In some breeds, pedigree and performance details have been collected for more than 30 years. Approximately 100,000 calves per year are being added to these databases where BREEDPLAN calculates Estimated Breeding Values for up 17 performance traits.

Traits potentially recorded are:

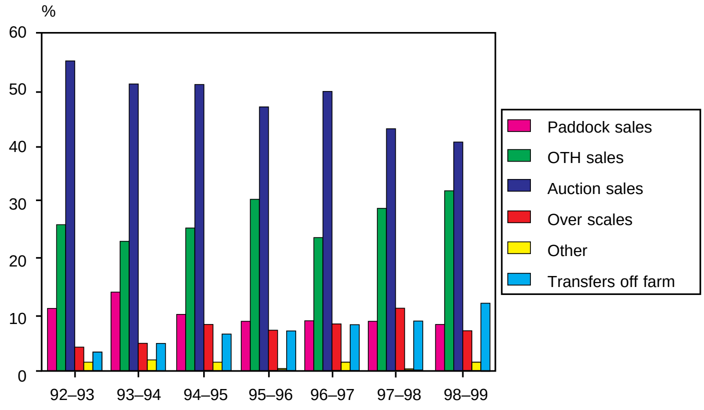
- Birth weight;
- Gestation length;
- Weaning weight;
- Yearling weight;
- Final weight;
- Mature weight;
- Joining/mating details;
- Scrotal size/circumference;
- Ultra-sound scans for rib fat, rump fat, intra-muscular fat and eye muscle area;
- Abattoir carcass measures for carcass wt, fat depth, intramuscular fat/marbling and retail beef yield;
- Calving ease;
- Temperament.

There are also traits being developed:

- Crush exit speed (correlated to meat tenderness in Northern Australia cattle);
- Net feed efficiency.

Table 8. Australian cattle market specifications.

Market	Carcass weight range	P8 Fat range	Dentition	Marbling
Domestic supermarket	180–240	5–12	0 and 2T	0
Hotel and restaurant	230–280	5–12	0 and 2T	0
Korean	180–280	7–22	0–6T	0
European Union	240–320	7–22	0–4T	0
Grass-fed Japanese	300–400	7–22	0–6T	0
100D Japanese grain	300–400	7–22	0–6T	0
Long-fed Japanese grain	300–420	7–22	0–6T	YES



Source: ABARE

Figure 10. Beef cattle selling methods.

There are also a number of projects looking at potential gene markers in beef cattle. A gene marker for marbling (Genestar) has been identified and is being commercially marketed by Genetic Solutions, Brisbane.

Significant research programs are also undertaken in Australia on meat quality, cross breeding, breed differences, feed efficiency and various other aspects of the cattle industry.

Buffalo Population

Australia does not have an indigenous buffalo population. Less than 100 Swamp buffalo were imported mainly from Timor, Kisar and other Indonesia islands between 1820 and 1850. These animals became the foundation of the Australian feral buffalo population. Buffalo thrived in the uncontrolled subcoastal plains of Northern Australia and reached a maximum population of about 350,000 in the 1980s.

Between 1880 and 1956, Northern Territory (NT) buffalo were mainly harvested for their hides. Slaughter of buffalo for pet food began in 1958 and for human consumption in 1961. In the late 1980s, the Australian Government implemented a national Brucellosis and Tuberculosis Eradication Campaign (BTEC) to protect Australia's meat export market share. While buffalo did not show evidence of brucellosis, the incidence of tuberculosis averaged about 3% in the feral population (up to 20% in some coastal areas) and significant harvest slaughter was required before Australia was declared tuberculosis clear in about 1997. The BTEC campaign reduced the buffalo population to the current levels of about 40,000 to 50,000 head.

Basic statistics

The BTEC program reduced the population to approximately 14,000 head on farms in the NT. This has steadily increased to around 20,000 currently on farms. The residual feral herd number in tuberculosis-free areas has not been surveyed for about 15 years but is currently estimated to be between 15,000 to 30,000. The feral population mainly roams in the Top End of the Northern Territory (mainly in Aboriginal-owned Arnhem Land which lies to the east of Katherine and Darwin).

The farmed buffalo are spread over about 30–40 properties located in the Top End of the Northern Territory. However, buffalo farming is also conducted in all other Australian States except Queensland where State Government regulation prohibits it. Most of these southern buffalo farming ventures have been set up in the past 8 to 10 years.

The vast majority of Australia's buffalo are the Swamp variety with small numbers of Riverines imported mainly for cross breeding. However, a private farmer from Victoria imported approximately 100 head of Riverine buffalo from Bulgaria and Italy and has set up a buffalo dairy at Camperdown (Victoria) and on the Eyre Peninsula (South Australia). However, all excess animals are slaughtered and not made available to other herds for breeding.

Productivity information

The vast majority of buffalo meat production occurs in the Northern Territory where property sizes range from about 20 to 4000 head. Production is grass-based with most properties relying on native species and low pasture management for rearing their animals. Under these conditions, cow fertility rates are about 50% with cow weights being around 350–400kg.

These animals are generally aimed at the Brunei slaughter buffalo trade which currently accounts for about 2000 head per year — up from 600–800 head per year previously (Table 9). Larger bulls (>350 kg) get AUD1.25 per kg live weight ex-Darwin and go to the wet market. The more premium animals (340–390 kg with no more than 2 permanent teeth) get AUD1.35 per kg live weight ex-Darwin and are aimed at the Brunei super market trade.

Under improved pastures and management, cow fertility is 80% or higher with a 4–6 week joining period, cow weights are around 450–600 kg, intercalving intervals about 12–14 months (with culling of cows who are non-pregnant and dry) and gestation lengths between 320 to 330 days. While there is an 8–10% mortality rate of calves within the first week or so of life, this is usually due to mis-mothering (which can be induced by early tagging of calves) or mis-adventure (poor calving location, dingoes, etc). Intestinal worms and diseases are generally not a problem, particularly on good pastures. While animals will grow at 1 to 1.2 kg per day off pasture during the main growing period, calves average around 150–300 kg at 12 months of age, depending on breed and pasture quality. The Riverine cross or pure Riverine types are at the upper end of the scale.

The Australian buffalo domestic meat market is quite small and tends to be aimed at niche markets. Table 10 shows the number of buffalo slaughtered in the NT over the past 14 years. The BTEC program accounts for the high slaughter rates for much of the period, with more recent slaughter rates reflecting current domestic markets.

TenderBuff™ is a registered trademark of NT Buffalo branded meat aimed at restaurants, buffalo burgers, etc. While it only accounts for about

Table 9. Live buffalo exports from Darwin, Northern Territory.

Year	Brunei	W/Malaysia	Sabah	Sarawak	Total
1997	539	0	99	0	638
1998	690	0	0	287	977
1999	1134	1225	0	0	2359
2000	2162	337	0	0	2499

Source: Buffalo News, Dec 2000, Australian Buffalo Industry Council.

Table 10. Number of buffalo slaughtered in Northern Territory abattoirs.

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Count	10,499	25,366	20,257	12,051	8149	5425	4899	2103	1276	843	479	499	95	264

200 head per year in the Darwin market, TenderBuff™ attracts a premium price of AUD$3.10 per kg dressed weight. There are tight specifications (Table 11) for animals to achieve this price with severe discounts of 10–40% for animals missing one or more of the specifications. To reach specifications, animals will need to be at least finished on improved pastures. DPIF staff monitor the TenderBuff animals through the abattoir on slaughter day and also carry out the chiller assessment the following day.

Table 11. Tender buff meat specifications.

Specification	Acceptable limit
Carcass Weight (HSCW)	150–300 kg
Fat depth	3–12 mm at P8 site
Age	No permanent teeth
Carcass management	Electrically stimulated
Meat pH	Less than 5.8 after 18 hours hanging

Herd sizes in the other states are generally small with nearly all herds being less than 100 head. Growth rates of calves in the southern states is quite good with calves reaching 300–400 kg by 12 months of age. Intestinal worms may need to be controlled in areas that have a wetter climate. Cold tolerance is a problem in exposed and windy properties.

Other Australian States have small niche markets usually arranged by local butchers. Choice cuts tend to go to restaurants while the rest of the carcass is used in processing (salami, etc). The market is also limited by cattle meat substitution problems. The December 2000 price in New South Wales was $1.85/kg carcass weight.

Genetics and breeding programs

The NT DPIF runs a number of programs aimed at improving the buffalo industry in the Top End. They sponsor research programs as well as market development and industry awareness.

Genetic conservation of cattle and buffalo

All Australian cattle and buffalo are derived from imported animals/semen/embryos as there were no indigenous cattle or buffalo population prior to European settlement in the 1800s.

Acknowledgments

Significant sections of this paper were derived from the following sources:

- Australian Bureau of Statistics (http://www.abs.gov.au)
- Meat and Livestock Australia (http://www.mla.com.au)
- Australian Registered Cattle Breeders' Association (http://abri.une.edu.au)

Mr Barry Lemcke, Northern Territory Department of Primary Industries and Fisheries is acknowledged for supplying most of the buffalo information contained in this report.

Cattle and Buffalo Breeding in Bangladesh

M.O. Faruque[1] and A.K.F.H. Bhuiyan[1]

Abstract

Bangladesh had 21.18 million cattle in 1984 and now possesses 21.57 million cattle The cattle population in Bangladesh consists mainly of the indigenous deshi type. The country also has two varieties of dairy cattle, viz. Red Chittagong (RC) and Pabna Cattle (PC). There are no imported breeds or variety of beef cattle in the country. In 1998, Bangladesh produced 1.41 million metric tonnes of milk and 1,060,000 metric tonnes of beef. According to the agriculture and livestock census taken in 1984, Bangladesh had 0.46 million buffalo. The buffalo number now stands at 722,769 possessed by 270,228 households (1.52% of the total households of the country). The average number of buffalo per household is now 2.67. Recently, Ministry of Fisheries and Livestock set up a committee to take measures for genetic conservation of livestock including cattle and buffalo.

BANGLADESH is situated in the northeastern part of South Asia. It lies between 20° 34′ and 26° 36′ north latitude and 88° 1′ and 92° 41′ east longitude. Bangladesh is a deltic region of three mighty rivers—the Ganges, the Brahmaputra and the Megna. The country is mostly flat except for a range of hills in the northeast and southeast. The south frontier is guarded by the Bay of Bangle. Bangladesh has an area of 147,570 sq. km. with a population of 126 million.

The density of population per square kilometre is about 854 with annual population growth rate of 1.8%. At present, agriculture accounts for about 32% of national GDP at current price and employs about two thirds of the total labour force. Within the agriculture sector, the contribution of livestock is increasing day by day. The share of livestock within the agriculture sector has increased from about 7% to 12% during the past 10 years.

The topography of Bangladesh can be divided into four main ecological zones: rainfed or flood fed land, wet land, hilly land and coastal area. Bangladesh has about 14.5 million hectares of land, of which about 12.33 million hectares are used for cultivation throughout the year. Out of 2.23 million hectares of land, 1.153, 1.18, and 0.46 million hectares are used for homestead, forestry and pasture respectively. Bangladesh has now 17.83 million households of which 6.03 million households are non farming households. Within the farming households, 58.02%, 11.65%, and 1.67% are small farmers (>1.5 acre), medium farmers (1.5–7.49 acres) and large farmers (<7.50 acres) respectively. Out of the total households, 28.11% have no cultivatable land. Cattle, goats and chickens are the main sources of meat in Bangladesh. However, a considerable quantity of meat also comes from buffalo, sheep, pigs and ducks. The trend in meat production and consumption is presented in Table 1.

Table 1. Production of meat (metric tonnes) of different species.

Species	Year	
	1985[1]	1999[2]
Cattle	175,956	161,000
Buffalo	4,128	4,000
Goat	18,576	126,000
Sheep	774	3,000
Chicken	36,636	110,000
Duck	21,930	—
Pig	—	15,000*

[1]DLS; [2]FAO, *own estimation.

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Cattle Population

Basic statistics

Bangladesh had 21.18 million cattle in 1984 (Anon. 1984) and now possesses 21.57 million cattle (Anon. 1996). This huge number of cattle is maintained by 8,171,294 households, and this represents 45.83% of the households of the country. The average number of cattle per household for the whole country is 3.0 while that for small farmers (>1.5 acres), medium farmers (1.5 to 7.49 acres) and large farmers (<7.5 acres) are 2.0, 2.0 and 4.0 respectively. However in some milk pocket areas and commercial farms, the herd size is much higher.

The cattle population in Bangladesh consists mainly of the indigenous deshi type. There are also a number of crossbred cattle of different genotypes (crosses of Holstein, Jersey, Sahiwal and Sindhi with indigneous) which represents now about 2–3% of the total cattle population of the country. The country also has two varieties of dairy cattle, viz. Red Chittagong (RC) and Pabna Cattle (PC). The approximate number of Red Chittagong and Pabna cattle is about 5000 and 100,000 respectively. There are no imported breeds or variety of beef cattle in the country. Cattle, except in the institutional herds, commercial farm and hilly areas, are raised under a semi-intensive system. In the institutional herds and commercial farms, cattle are raised under an intensive system. In hilly areas, cattle are raised under an extensive system. In 1998, Bangladesh produced 1.41 million metric tonnes of milk and 160,000 metric tonnes of beef.

Productivity of cattle

Performance of various genotypes of the cattle are presented in the Table 2.

Cow milk in Bangladesh is marketed into two ways. In the traditional method, milk is marketed by milkmen as fluid milk to consumers. They also supply a part of the fluid milk to sweetmeat shops where milk is used for preparation of sweetmeats and yoghurt. On the other hand, companies such as BMPCUL, BRAC and some other enterprises make pasteurised milk, powdered milk, yoghurt, ice cream and milk drink. They sell their products in towns and cities.

Meat is marketed in the traditional method. Indigenous (Deshi) bulls and aged cows are slaughtered. About 0.25–0.30 million bulls aged between 3–6 years are slaughtered during the great one-day festival of the Muslim community. These bulls are produced through beef fattening in different parts of the country. The average live weight and dressing percentage for Deshi cattle are 233 kg and 44% respectively. Also, aged and culled bullocks coming through the migration process from India are slaughtered regularly in the local markets.

The problems associated with cattle production are: (i) poor genetics and lack of a sound and consistent breeding policy; (ii) lack of animal recording and a genetic evaluation system; (iii) inadequate nutrition (iv) insufficient health care services of Directorate of Livestock Services (DLS); (v) noncommercialisation of the cattle industry

Genetics and breeding program

Bangladesh has now seven institutional herds under the DLS, one institutional herd under BLRI and one institutional herd under BAU. These institutional herds maintain about 5000 cattle of different genotypes, viz. Red Chittagong cattle, Pabna cattle, Sahiwal, Holstein, Sahiwal cross, and Holstein cross. In addition to these institutional herds, there are a number of commercial farms in and around the big cities like Dhaka, Chittagong, Khulna etc. In 1996, there were about 26,000 commercial dairy farms in the country. However the number has now reduced to about 300 only. These commercial farms possess mainly F_1 or F_2 Holstein crosses. Bangladesh Milk Producer Cooperative Union Ltd. (BMPCUL) established in 1964, also maintains registered herds at farmer level in four milk pocket areas and has more than 100,000 registered cattle. Recently, Bangladesh Rural Advancement Committee (BRAC), a NGO, and three private cooperatives have started similar functions to BMPCUL; however, the exact number

Table 2. Performance of different genotypes of cattle.

Traits	RC	Pabna	Sahiwal	Holstein	HL[2]	SL[3]
Birth weight (kg)	16	18	18	27	19	18
Age at 1st heat (monthly)	30	32	36	18	24	34
Age at 1st calving (monthly)	49	48	50	40	45	44
Lactation length (days)	245	265	308	340	393	236
Lactation yield (kg)	550	727	1500	3000	1800	1239
Average daily milk yield (kg)	3	4	5	11	6.5	5
Calving interval (days)	384	437	424	464	425	386

[1]Red Chittagong [2]HL Holstein/indigenous cross [3]SL Sahiwal/indigenous cross

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of farmers and cattle involved in their program is not known. The NGO, private farms and companies maintain the milk and health records. In institutional herds and BMPCUL milk, pedigree and health records are maintained. However, ICIAR approved methods for animal recording are yet to be followed in Bangladesh.

Bangladesh has a long history of importing exotic germ plasm as shown below:

1930–1937: Hariana; 1937: Hariana, Sindhi and Sahiwal; 1960: Sindhi, Sahiwal and Tharparker; 1967: 50% Holstein and Jersey; 1973: Holstein and Jersey (Australia); 1987: Sahiwal; 1989: Holstein from Spain; 1992: Sahiwal; 1992: AFS from Australia; 1983: frozen semen from Germany, New Zealand and Kenya; 1987: frozen semen from Australia and New Zealand, 1990—2000: frozen semen of Freisian from France, USA etc. (Bhuiyan 1997).

The existing breeding program as adopted in 1982 was (i) breed females of urban, semi-urban and milk pocket area with 50% Friesian–50% Sahiwal/ indigenous bulls; (ii) breed females of the rural areas with 50% Friesian–50% indigenous bulls. However in commercial farms, 100% Friesian was being used. In 1999, the breeding policy was revised, so that for extensive traditional farming, semen of improved indigenous germplasn and for intensive dairying, semen of 50% Freisian–50% indigenous has been recommended.

This policy is being executed through one Central Cattle Breeding Station (CCBS), 23 A.I. centres, 420 sub-centres and about 550 A.I. points. The outcome of the past policy was not satisfactory and so a new breeding policy was formulated. BMPCUL and BRAC have started recently to implement their own breeding policy. They have introduced A.I. through the establishment of bull stations and the use of imported semen.

Bangladesh has also tested the possibility of adapting MOET technology at the government nucleus. The first set of progeny through MOET by non-surgical techniques has been produced at CCBS recently. Though an excellent permanent beef market exists, any beef genetics is yet to be imported into Bangladesh

Buffalo Population

Basic statistics

According to the agriculture and livestock census taken in 1984, Bangladesh had 0.46 million buffalo. The buffalo number now stands at 722,769 (Anon. 1996) possessed by 270,228 households (1.52% of the total households of the country). The average number of buffalo per household is now 2.67. The number of buffalo per household possessed by the small, medium and large-scale farmers are 2.41, 3.0 and 3.49 respectively. About 35% of the total buffalo of the country is possessed by the medium-scale farmer. However, in the coastal areas, some families have up to 600 buffalo. The buffalo population can be divided into following types/breeds.

(a) Indigenous river types 433,200 head;
(b) Bangladeshi Surti 4500 head;
(c) Indigenous Swamp 37,500 head;
(d) Cross bred (NiliRavi Cross) 40,000 head;
(e) Non descriptive type 207,569 head;
(f) NiliRavi 120 head.

These buffalo are raised in particular agroecological zones, i.e. the sugarcane belt, in marshy land, in the coastal area and the sandy islands of the Brahmaputra river. In the sugarcane belt, buffalo are used for draught purposes and the population is composed predominantly of male buffalo. In the coastal area and Brahmaputra river basin, buffalo are used for milk and draught purposes. In these areas, the buffalo population is composed of both male and female, as shown in Table 3.

Table 3. Buffalo number by sex for selected regions of Bangladesh.

Location	Buffalo number					Total
	Milchcow	Drycow	Heifer	Calves	Bull/bullock	
Trisal	55	19	20	49	3	146
Nandina	5	4	6	7	1	23
Mathergonj	65	30	12	62	3	172
Dhunat	110	51	33	77	3	274
Ramhati						
Upper part	60	74	65	40	116	355
Lower part	581	416	366	320	15	1698
Amtali	54	59	52	46	98	309

* *Source:* Faruque 2000

In the marshy land, buffalo are used for draught and meat purposes. Except for the lower part of the coastal areas, buffalo in Bangladesh are raised under a semi-intensive system. However, little concentration is given to buffalo through this system. Buffalo in the lower part of the coastal area are raised under an extensive management system. In 1998, Bangladesh produced 22,000 metric tonnes of beef meat and around 4000 metric tonnes of buffalo meat.

Productivity of buffalo

The productivity of different types of buffaloes is given in Table 4.

The gestation period of the Surti buffalo is 309 days. The calving interval for the same is 389 days.

Buffalo milk in Bangladesh is used mostly for the preparation of yoghurt and cheese. Milking is done by the farmers or cowboys. Milk is sold to the market directly by the farmers or by milkmen. Buffalo meat is not generally sold as buffalo meat in the cities and towns. In the villages, buffalo are slaughtered like cattle and sold openly in the market. Usually, the aged and culled buffalo are slaughtered. A butcher purchases one buffalo from the nearby animal market and sells the meat throughout the day.

There are a number of problems associated with buffalo production and improvement in Bangladesh. These are: (i) the existing buffalo production system does not match the present socio-economic trend; (ii) there is no supplementary ration for dry period and there is no calf starter for calf raising; (iii) health care service of the DLS is insufficient; (iv) no scientific record keeping system exists; (v) lack of appropriate buffalo breeding policy; (vi) there is no organised marketing system for milk and meat production.

Genetics and breeding programs

Bangladesh has now only three recorded herds of buffalo: (i) a herd of 198 buffalo maintained at the Buffalo Breeding Farm under DLS; (ii) a herd of 26 buffalo maintained at the Dairy Farm of Bangladesh Agricultural University (BAU); and (iii) a head of 460 buffalo under a cooperative system in different villages maintained by Department of Animal Breeding and Genetics since 1997.

Before 1960, buffalo breeding in Bangladesh was based on a straight breeding program carried out by farmers themselves. The crossbreeding program with Nili-Ravi started in 1960. For this, Nili-Ravi bulls have been distributed in the coastal area for producing crossbred progenies through natural mating. The same was done through A.I. by BAU from 1960 to 1978. However, there was no program to follow the performances of crossbred progenies at field level. In the absence of any organised and planned program, selection is being done on mass selection at all levels.

In March, 2001, The Ministry of Fisheries and Livestock, Government of Bangladesh agreed in principle to formulate a National Buffalo Development Program (NBDP) for the first time. It is aimed at systematic genetic improvement through planned breeding programs that will come into force throughout the country in the near future.

Genetic conservation of cattle and buffalo

The Red Chittagong cattle, Bangladeshi Surti and swamp buffalo demand genetic conservation. Bangladesh Agricultural University Dairy Farm has collected a number of Red Chittagong cattle and Bangladeshi Surti for multiplication and conservation. DLS has also collected Red Chittagong cattle

Table. 4. Performances of buffalo.

Traits	Indigenous river	Surti	Indigenous swamp
Growth rate (kg/day) (overall)	0.270	0.245	0.270
Age at maturity (months)	48	42	55
Body height, male at birth (cm)	73	–	–
Body height, mature male (cm)	123	–	–
Body height, female at birth (cm)	72	70	72
Body height, mature female (cm)	121	126	125
Lactation length (days)	275	272	240
Lactation yield (kg)	590	812	280
Fat (%)	7.15	–	–
Protein (%)	4.6	–	–
Liveweight at slaughter, male (kg)	379	–	–
Age at slaughtering (years)	>9	–	–
Carcass yield (%)	42	–	–

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for conservation purposes. There is no attempt to conserve the swamp buffalo at present. Recently, Ministry of Fisheries and Livestock has set up a committee to take measures for genetic conservation of livestock including cattle and buffalo.

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Current Situation and Development Trend of Beef Industry in China

Zeng Qingkun[1], Yang Bingzhuang[1], Shang Jianghua[1] and Qin Jing[1]

Abstract

Chinese cattle and buffalo have rich resources and good meat performance, but these have not been exploited fully. In the past 10 years, the development of beef production has been improved greatly as a result of Government policy. With the development of technology and an increasing standard of human life, there should be an increasing demand for higher quality beef, and the beef industry in China has the prospect of greatly expanded development.

THE STATISTICS of the 5th census in 2000 enumerated more than 1.295 billion people in China, being the largest population in the world. The Chinese Government began a process of family planning in 1980, thereby limiting the growth rate of the human population to 1% (Anon. 2000).

Land Resource

China has a total area of 9.6 million sq. km., representing one-fifteenth of the world land mass, with two-thirds being mountainous areas and 10.3% arable lands (Table 1).

Table 1. Land resource and use.

Types	Area (ha)	% of total land
Total area of land	960,000,000	100.0
Cultivated land	99,400,000	10.3
Agricultural barren	26,700,000	2.8
Pasture	286,000,000	29.8
including available land	223,300,000	23.3
Grassland brae	44,700,000	4.7
Land for towns, roads etc.	66,700,000	6.9

Source: Yearbook for the Peoples Republic of China in 1998 (Anon. 1998).

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Meat Consumption Comparison

Historically, cattle in China were used mainly for draught purposes with a low use rate, resulting in a restricted beef market supply. Beef consumption per capita in 1996 was only 3.29 kg while pork was 17.24 kg as the daily meat food (Table 2). In recent years, beef consumption with low fat and high protein has increased as people change their traditional diet.

Table 2. Meat consumption comparison (unit: kg/per person per year).

Product	Year		
	1994	1995	1996
Pork	17.12	17.24	17.24
Beef	3.10	2.44	3.29
Poultry meat	4.13	3.97	3.97
Fresh egg	9.68	9.37	9.64

Source: Yearbook of Chinese Food Industry in 1997 (Anon. 1997).

Agricultural Development Policy

Although the land area of China is the third largest in the world, the cultivated land per capita is only 0.073 ha, due to the large population. To solve the problem of food supply, it is necessary to develop an agriculture with high yield, efficiency and quality, particularly expanding economic herbivore industries. The Chinese Government now attaches great importance to the dairy and beef industries and continuously makes relevant policies for industrial development.

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Cattle Population

Basic statistics

According to FAO estimates from 1991 to 2000, the figures for cattle in China are increasing dramatically. The population increased from 59.616 million to 81.983 million, with 3.8% average annual growth rate; the beef yield increased from 1.579 million tonnes to 5.023 million tonnes with 21.8% average annual growth rate; the milk yield increased from 5.653 million tonnes to 9.009 million tonnes with 5.9% average annual growth rate (Table 3) (Anon. 1991–2000).

There are 26 Chinese native cattle breeds that were historically used for draught purposes. A study during the past 20 years shows that Chinese native cattle produce high quality meat, which has gradually changed their use from draught to meat and milk purposes. In order to improve the production performance of cattle, more than 10 famous fine exotic breeds for meat and/or milk type were introduced to China and crossbred with native breeds. This has improved the meat and milk performance of native cattle. At present in China, native and crossbred beef cattle represent 15% of total bovine herds (Zan et al. 1999).

Productivity Information

Meat performance of cattle

After fattening, the dressing percentage of Chinese cattle is equal to speciality beef cattle breeds. For example, the dressing percentage of Qinchuan Cattle and Jinnan Cattle are 64.22% and 63.44%, respectively (compared to Limousin 64%, Angus 65%, Charolais 67%, Shorthorn 65%, Hereford 59.8%, Helvetic Simmental 62.9% and German Simmental 62.9%); the meat percentage is over 53% (Table 4). These figures show that the purebred Chinese cattle breed has fine meat performance. Previously it was considered that the dressing percentage of Chinese cattle was low, due to not having a proper fattening period.

Table 3. The volume of rearing and sales and beef yield in cattle.

Items	Unit	1995	1996	1997	1998	1999	2000
Rearing	head	77,627,672	75,861,129	69,102,938	76,850,267	79,198,309	81,983,409
Beef yield	t	3,296,374	3,333,490	4,105,401	4,485,381	4,710,873	5,022,873
Milk yield	t	7,257,517	7,891,387	7,644,204	8,016,726	8,644,380	9,009,275
Slaughter	head	23,443,440	22,916,420	29,690,104	32,585,292	34,086,816	35,787,816
Avg carcass weight	kg	140.6	145.5	138.3	137.7	138.2	140.4

Source: FAO statistics (Anon. 1991–2000).

Table 4. Score of dressing percentage of Chinese cattle.

	Breeds								
	Qinchuan (castrated)			Jinnan (castrated)			Yanbian (castrated)		
Items	n	$\overline{X}$	$s_{\overline{X}}$	n	$\overline{X}$	$s_{\overline{X}}$	n	$\overline{X}$	$s_{\overline{X}}$
Live weight before slaughter (kg)	30	565.03	45.04	30	541.87	45.58	10	535.00	42.47
Carcass weight (kg)	30	363.25	32.85	30	343.98	32.99	10	328.00	28.27
Dressing percentage (%)	30	64.22	2.21	30	63.44	2.07	10	61.29	1.25
Meat weight (kg)	25	306.44	29.48	25	292.75	30.77	10	273.66	26.70
Meat percentage (%)	25	54.54	1.71	25	54.20	1.84	10	54.20	1.60
	Breeds								
	Ke'erqing			Fuzhou			Bohai		
Items	n	$\overline{X}$	$s_{\overline{X}}$	n	$\overline{X}$	$s_{\overline{X}}$	n	$\overline{X}$	$s_{\overline{X}}$
Live weight before slaughter (kg)	15	576.26	68.79	10	585.80	66.35	12	501.25	44.22
Carcass weight (kg)	15	356.09	46.03	10	362.98	37.62	12	318.72	28.85
Dressing percentage (%)	15	61.73	1.49	10	62.05	1.58	12	63.59	1.75
Meat weight (kg)	15	300.02	40.91	10	302.21	33.56	11	270.63	24.71
Meat percentage (%)	15	51.94	1.61	10	51.62	1.25	11	53.37	1.89

Source: Jiang 1996.

Market details

In general, beef cattle bulls on large farms are sold at age 3 with a weight of over 480 kg; while dairy cattle are older than beef bulls when they are slaughtered, usually after moderate fattening.

According to the rules, the animals should be brought to abattoirs to ensure the public health. Normally, beef is delivered to market while fresh.

In recent years, China has made a standard for the grading of beef, which is referred to as high quality cattle for production and this has promoted exports.

Constraints to production

Differences of seasonal weather, disease and feeding modes are the main constraints to production.

Genetics and Breeding Program

Breeding record

The Fine Breed Record is established in many large farms, bases and project areas. The items recorded include animal ID, date of birth, pedigree (such as ID and production performance of sire and dam), production performance, exterior score, body measurement, body weight, genetic index and general performance index.

Source of new genetics

More than 10 exotic excellent dairy and meat breeds were introduced consecutively into China, including Holstein, Simmental, Limousin, Charolais, Hereford, Shorthorn and Angus, resulting in improvements to some Chinese cattle breeds crossbred for improved milk and meat performance.

National breeding programs

Breeding objectives

To produce fine milk and meat type cattle by the way of pure-breeding and crossbreeding.

Breeding index

Milk performance index: 305-day milk yield is close to or reaches advanced international levels with over 3.1% of milk fat rate and 2.9% of protein percentage.

Meat performance index: approximately 400 kg for adults, over 55% dressing percentage and over 45% of meat percentage.

Development trend of cattle

Average annual beef and milk consumption rates per capita are far less than the mean world level. Cattle is the main source of beef and milk at present and will be long into the future. Therefore, cattle will be the main item for development strategies, which have encouraging prospects for the future.

Beef cattle development is aimed at improving meat performance and quality so that it can achieve a larger percentage in the human meat diet; while dairy cattle development is aimed at increasing milk yields and contents (Zhou 2000).

For the potential development of the Chinese beef cattle industry, feeding management strategies should be enhanced, and fine exotic beef breeds should be imported for crossing with cattle with low productivity for improvement of meat performance and beef quality. On the other hand, selection of Chinese cattle should be improved for developing the excellent Chinese beef cattle breeds.

Buffalo Population

Basic statistics

According to FAO estimates, buffalo are reared in 18 provinces of China and the population increased slightly from 21.712 million in 1991 to 22.599 million in 2000, currently representing 21.6% of the total bovine population in China (Anon. 1991–2000). The average annual growth rate of 0.41% is lower than the average annual world growth rate (1.04%) (Table 5).

Table 5. Volume of rearing and sales and output of meat and milk in buffalo.

Items	Unit	1995	1996	1997	1998	1999	2000
Rearing	head	22,928,259	23,597,103	21,733,463	22,556,688	22,676,620	22,598,620
Slaughter	head	3,007,502	2,507,297	3,246,209	3,387,463	3,667,685	3,605,685
Meat yield	t	301,625	251,582	325,565	339,403	367,403	361,403
Avg carcass weight	kg	100.3	100.3	100.3	100.2	100.2	100.2
Milk yield	t	2,200,000	2,300,000	2,450,000	2,450,000	2,450,000	2,450,000

Source: Science of Chinese Buffalo (Zhang et al. 2000).

There are 18 Chinese native buffalo breeds, which are swamp type. They were used for draught due to their low performance in terms of milk and meat. In the past 20 years, the milk and meat performance of buffalo has been improved by the way of cross-breeding and selection, and their use has changed from draught to use for milk and meat purposes.

Productivity Information

Growth development and meat performance of buffalo

Growth rate is similar between Chinese native buffalo and exotic river type Murrah and Nili-Ravi buffalo during the first two years, but higher in crossbred buffalo with a crossbreeding advantage (Table 6). The body weight of adult native buffalo is less than that of Murrah and far less than Nili-Ravi buffalo by more than 200 kg (Table 7).

Market details

Generally, without identifiable standards, buffalo are slaughtered at 24 months after a moderate fattening period. They are gathered and quarantined like pigs by commercial slaughter companies to ensure that the animal sold is healthy and then delivered to the terminal markets.

Due to the requirements of the human diet and the limitations of equipment in slaughter houses, meat is supplied to market fresh. Frozen product is low in quality.

Constraints to production

Instead of seasonal weather and diseases, the main influences on buffalo production are rearing in small herd sizes, poor quality feed, with low levels of management resulting in slow growth rate, small body weight and low production performance. This is unfortunate in light of the fact that Chinese buffalo have the third largest population in the world.

Genetic and Breeding Programs

Breeding record of buffalo

The Fine Breed Recording Scheme is established in animal breeding farms, householder and countryside

Table 6. Reproductive and production performance of some buffalo.

Items		Binhu	Fulin	Guizhou	Murrah	Nili-Ravi	Murrah crossbred	Nili-Ravi crossbred	Crossbred
Calving interval (days)		450	447.5	839.5	471.4	531	535	481.2	506.2
Weight at 12 months	male	0.71	0.63	0.62	0.65	0.64	0.63	0.45	0.78
(kg per day)	female	0.62	0.60	0.55	0.55	0.6	0.51	0.61	0.72
Weight at 24 months	male	0.46		0.38	0.43	0.42		0.45	0.6
(kg per day)	female	0.43		0.36	0.48	0.49		0.58	0.58
Weight of adults (kg)	male	547.8	491.7	487.1	888.0	821.1	473.2		922.5
	female	485.0	446.5	428.9	622.4	659.8	486.7	642.6	662.1

Source: Science of Chinese Buffalo (Zhang et al. 2000).

Table 7. Meat performance comparison of buffalo bulls.

Items	Age (months)	Weight before slaughter (kg)	Carcass weight (kg)	Meat weight (kg)	Dressing percentage (%)	Meat percentage (%)	Meat-bone ratio	Loin-eye muscle area (cm^2)
Native	19–21	216.0	109.8	85.0	50.8	39.3	1:3.4	40.7
Murrah crossbred F_1	24	447	251	190.4	56.2	42.6	1:4.8	156
Nili-Ravi crossbred F_1	18	398.0	205.6	165.5	51.9	41.3	1:4.1	
Nili-Ravi crossbred F_2	26	361.0	206.1	173.5	57.1	48.1	1:4.9	
Triple-crossbred	18–24	440.7	230.6	187.0	52.4	42.4	1:4.5	75.1
Triple-crossbred F_1	19–27	313.3	170.3	132.8	54.4	42.3	1:3.8	47.9
Murrah	19–24	292.0	210.9	164.5	53.7	41.9	1:3.6	
Nili-Ravi	19–24	436.7	219.1	171.9	50.1	39.3	1:3.6	

Source: Science of Chinese Buffalo (Zhang et al. 2000).

demonstration areas where buffalo are reared. The selection index is a main component combined with the pedigree index and total performance index. The fine breed records of buffalo includes ID of animal, date of birth, hair color, current pregnancy number (age), pedigree (ID of dam and sire and milk performance of dam), milk performance (years, pregnancy numbers, fat rate of 305-day milk yield), overall type score, body measurement, body weight, genetic index and total performance index. The buffalo are registered in the fine breed record only if they measure up to one of the following:

a. one or more items on the buffalo breeding indexes;
b. the reservation value of genetic index for the calves selected by genetic indexes;
c. 100% of total performance indexes for the calves selected by total performance index, from which the males as elite bulls are used for breeding and the females as breeding dam are incorporated into breeding nucleus herds; and
d. mean value or more of production trait indexes for crossbred females producing offspring by inter se breeding, as breeding herd, from which those in excess of mean value of breeding herd in terms of production trait indexes are selected into breeding nucleus herds. Both of the two herds are registered in the fine breed record.

Source of New Genetics

Murrah buffalo from Indian and Nili-Ravi buffalo were introduced to China from Pakistan in 1957 and 1974, respectively. Of these, the population has increased from tens originally to hundreds now by way of pure-breeding and selection for over 20 years and from which frozen semen has been produced. The Buffalo Research Institute in Guangxi Province of China used these two river type breeds for cross-breeding with native buffalo. The average milk yield at 305 days of triple-crossbred buffalo has reached more than 2100 kg and even more than 3800 kg for the top individuals. The dressing percentage and meat percentage of buffalo bulls are 54.4% and 42.2% respectively.

The Government of India gave a batch of Murrah buffalo semen as a present in 1995. This is currently being used at the Buffalo Research Institute in Guangxi, which has a good history of pure-breeding of Murrah buffalo.

Breeding programs

Breeding objectives

To breed new buffalo varieties for the dual purposes of milk and meat.

Breeding methods

Two breeds cross combination model: using updating cross-breeding methods; and three breeds cross combination model: using growing cross-breeding methods.

Breeding index

Milk performance index: 1500 kg of milk yield at the first lactation for 305 days and 7.0% of milk fat rate.

Meat performance index: over 350–400 kg of weight at age of 1824 months, more than 50% of dressing percentage and more than 40% of meat percentage.

Distribution of buffalo breed improvement

Different production demonstration areas are conducting breeding programs in order to improve the development of buffalo breeding and production. For instance, frozen semen are supplied to the corresponding breeds or types by provincial or city breeding improvement stations according to a pre-determined distribution program.

Private breeding program

Either pure-breeding or crossbreeding is conducted according to current situations and conditions in different areas.

Breeding policy

Developing buffalo for the dual purposes of milk and meat is an efficient way to solve the problem of limited milk and meat supplies in south China.

The Chinese Government is concerned with development and utilisation of the buffalo resource. In October 1974, the former Science and Education Bureau of the Agriculture Ministry organised 14 provinces to conduct a Buffalo Production Workshop in Nanning city of Guangxi province. In the course of this meeting, a Coordination Group for National Buffalo Improvement and Breeding was established to organise and coordinate national scientific research and production of buffalo. In September 1987, the former Livestock Husbandry Bureau of the Agriculture Ministry held a Buffalo Development and Utilisation Workshop in Beijing to conduct preliminary planning and then established a National Group of Buffalo Development Projects and Team of Experts in April 1989. In July 1991, the former National Scientific Technology Committee distributed a Buffalo Dairy Development Project to both Guangxi and Guangdong provinces. In 1996, the Central Dairy Project Office of the Agriculture Ministry organised three provinces of Guangxi, Yunnan and Guangdong to carry out the China-EU Buffalo Development

Project for crossbreeding improvement and breeding, technical training, dairy development and milk processing for buffalo. Moreover, the Chinese Government listed the development of beef, buffalo and dairy buffalo as part of 2001–2005 National Economic Development Planning. With the aid of the Government, the buffalo industry has been improved greatly. At present, Guangxi province has the largest buffalo population (4,800,000) in China.

Future development trends

- Develop native buffalo in south China from draught use to meat performance, in particular those with fine genetic characters such as large body size and high growth rate, for improvement of performance and quality by way of short term fattening.
- Enhance selected buffalo herds with high milk performance by pure-breeding or crossbreeding for milk purposes, promoting the dairy development of buffalo in suitable areas.
- Strengthen the breeding and conservation of the fine breed buffalo resource. Using biotechnology such as MOET to speed up the breeding of fine buffalo for promoting buffalo breed improvement.

Genetic Conservation of Cattle and Buffalo

Comparison trials for many years by Chinese researchers have shown that beef from Chinese cattle slaughtered after fattening reaches the level of special beef cattle in terms of all indexes, with characters of top quality, special flavor, tenderness and succulence; while the daily gain of some Chinese buffalo breeds at the age of 24 months is equal to that of exotic fine breeds. This indicates that Chinese cattle and buffalo are good genetic resources with good meat performance.

Genetic conservation of cattle and buffalo is realised through reservation of live animals, preservation of frozen semen and embryo and the establishment of a gene bank.

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Beef Production in India

Kiran Singh[1]

Abstract

India has less than 3% of the world's total land area but supports 55% of the world's buffalo, 16% of the world's cattle; 20% of the world's goats and nearly 4% of the world's sheep. Cattle and buffalo husbandry in India is a multi-purpose system in which these animals are used mainly for milk, draught and organic manure purposes. When there is no utility on any of these accounts or there is no profitability and animals become a burden on the farmer, these culled and spent animals are used for meat purposes. In cattle breeding, most state governments are resorting to crossbreeding with the semen of exotic breeds like Holstein Friesian, Brown Swiss and Jersey. Holstein Friesian is the breed of choice. However, in hilly and heavy rainfall areas, Jersey has been recommended. Semen of the exotic breeds is the source of new genetics. For superior indigenous breeds, selective breeding has been recommended but in certain areas crossbreeding with the semen of exotic breeds is being practiced using the females of indigenous purebreds. For genetic conservation purposes, survey, characterisation, conservation and improvement programs for various indigenous breeds have been taken up under a Network Project on Animal Genetic Resources. The objective is to determine population status, socio-economic conditions and breed characteristics and to undertake a conservation program for breeds whose number is on the decline.

INDIA is the largest livestock-holding country in the world and its present livestock inventories exceed 470 million, based on an annual growth rate of more than 1.5% per annum from the last official livestock census in 1992.

India constitutes less than 3% of the world's total land area whereas it supports 55% of the world's buffalo, 16% of the world's cattle; 20% of the world's goats and nearly 4% of the world's sheep. At present, livestock and livestock products account for 26% of India's agricultural output. Though the share of agriculture in India's GDP has been falling, the value of the output from livestock products is going up.

The dairy sector accounts for 66% of livestock products in terms of value. Animal husbandry and dairying are playing a vital role in rural economy. At current prices, the gross value of the output from this sector has gone up from Rs. 42,040 crores in 1990–91 to Rs. 82,704 crores in 1995–96 accounting for over 26% of the total agricultural output excluding animal draught power output. India's export earnings from the livestock sector rose from Rs. 691.22 crores in 1987–88 to Rs. 1930 crores in 1995–96.

The livestock are of considerable diversity to withstand environmental stress and inadequate levels of nutrition and management. India possessed almost 10% of all the recognised breeds of cattle, 100% of buffalo breeds, 30% of goat breeds and 15% of the sheep breeds in the world. Though India has the largest livestock population in the world, its genetic quality and productivity is poor due to unscientific feeding and management, unorganised breeding, inadequate nutrition and unmotivated tranfer of technical developments from institution to farms.

A majority of livestock consists of low milk-yielding non-descript cows and buffalo, profusely fed on crop residues and natural herbage and roughage without supplementation with costly concentrates due to scarce land for pastures and forage production and high cost of feed concentrates.

Milk production per animal is usually higher in areas where there is balanced and mixed farming. The best milk animals are found in areas where agriculture is prosperous and cultivated fodder, coarse cereals and oilseed milling by-products, crops residues, etc. are easily available and where pressure on land is comparatively low.

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Table 1. Livestock population (millions).

Species/Period	1961	1966	1972	1977	1982	1987	1992
Livestock	335.40	344.10	353.40	369.00	419.59	445.28	470.14
Cattle	175.60	176.20	178.30	180.00	192.45	199.69	204.53
Buffalo	51.20	53.00	57.40	62.00	69.78	75.97	83.50
Sheep	40.20	42.00	40.00	41.00	48.76	45.70	50.80
Goat	60.90	64.60	67.50	75.60	95.25	110.21	115.28
Pig	5.20	5.00	6.90	7.60	10.07	10.62	12.79
Poultry	114.20	115.40	138.50	159.20	207.74	275.32	307.07

Source: Livestock Census, DES.

The availability of feed concentrate in the country at present is estimated at 42 million tonnes against a requirement of about 80 million tonnes. The availability of green fodder is estimated at 574 million tonnes against a requirement of 745 million tonnes. The major reason for this shortage is increasingly human pressure on cultivable land, indiscriminate grazing leading to degrading of grazing lands and difficulties in obtaining certain feed ingredients in required quantities at reasonable prices throughout the year.

The Government is considering the formulations of national livestock policy for up-grading of genetic stock and for elimination of unproductive cattle. The Union Government has constituted and appointed a working group to review cattle and buffalo breeding policy and to recommend a new policy.

As such, India does not have beef cattle in conventional definitions as practiced in western and other developed countries except some pockets like North East Hill Regions where most of the cattle and buffalo are reared predominantly for meat. Most of the beef production in India is based on culled and spent cattle and buffalo.

The estimate of the human population was 966.192 million in 1997, 982.223 million in 1998 and 999.82 million in 1999. The total land are is 328.73 million hectares, and total grazing pasture is 11.4 million hectares. Arable land was 149.79 million hectares in 1997, 150.10 million hectares in 1998 and 151.10 million hectares in 1999.

Cattle Population

Basic statistics

There are 30 well defined breeds of cattle in India. However, specific breed populations are not known because the 5-yearly census considers species rather than individual breeds. The cattle population in different census years is given in Table 1.

Native vs crossbreds

Population of indigenous and crossbred cattle (millions) is given in Table 2.

Table 2. Population of indigenous and crossbred cattle (millions).

Cattle	Year	
	1982	1987
Native	180.40	188.28
Crossbreeds	8.80	11.41

Number of herds/animals per herd

No herd of cattle is being maintained exclusively for the production of beef. The numbers of herds of different breeds of cattle in the country being maintained for production of milk and bullocks are given in Table 3:

Table 3. Number of herds of different breeds of cattle maintained for production of milk and bullocks.

Breed	No. of farms
Amritmahal	1
Deoni	5
Gaolao	1
Gir	21
Hallikar	1
Hariana	19
Kangayam	1
Kankrej	9
Khillari	3
Malvi	2
Nagori	1
Nimari	2
Ongole	4
Rathi	6
Red Sindhi	16
Sahiwal	21
Tharparkar	11
Umblachery	1
Vechur	1

Cross breeding vs. purebred

Out of the total cattle population of around 200 million, the crossbreds constitute around 7%. As many as 80% of the cattle belong to the non-descript category and 20% of the cattle belong to well defined breeds of cattle.

Cattle population trend

The population trend for cattle and other species of livestock producing meat is given in the Table 4.

Table 4. Livestock population annual growth rates (%).

Species/period	1951–72	1972–92	1951–92
Livestock	0.94	1.44	1.19
Cattle	0.69	0.69	0.69
Buffalo	1.41	1.89	1.65
Sheep	0.11	1.20	0.66
Goat	1.80	2.71	2.26
Pigs	2.28	3.13	2.70
Poultry	3.22	4.06	3.64

Production information

Meat production in 1998 was 1,400,800 tonnes, 1,421,400 tonnes in 1999 and 1,442,100 tonnes in 2000. Milk production in 1998 was 35.5 million tonnes, 36.0 million tonnes in 1999 and 30.9 million tonnes in 2000.

Main use

None of the breeds is used for production of beef in India due to a legal ban on the slaughter of cows. The well-defined breeds of cattle and non-descript animals are mainly used for milk, draught and manure.

Productivity information

Productivity/performance

Information on birth weight and adult body weight for different breeds of cattle is given in Table 5.

The reproduction performance of various breeds of cattle is given in Table 6.

Table 5. Birth weight and adult body weight for different breeds of cattle.

Breed	Birth weight			Adult weight	
	Male	Female	Overall	Male	Female
Amritmahal	20.8	19.9		500	318
Bachaur	19.7	18.8		385	318
Bargur	18.9	18.1		340	295
Dangi	18.4	17.5	17.9	363	310
Deoni	23.0	23.4		590	340
Gaolao	19.3	18.5		430	340
Gir	23.1	21.3	23.9	544	309.8
Hallikar	21.3	20.2		340	227
Hariana	23.34	21.73	22.4	499	325
Kangayam	22	21	21	540	380
Kankrej	24	23	23.0	343	
Kenkatha	19.2	18.9	—	350	300
Kherigarh	20.7	19.9	—	476	318
Khillari	22	21.3		499	334
Malvi	21	19	19.9	499	340
Nagori	17.5	16.3	16.9	362.9	317.5
Nimari	19.9	18.7		390	318
Ongole	28	26	26.8	570	
Ponwar	17.6	—	—	318	295
Punganur	12.8	11.4	12.3	244	178
Rathi	19.4	19.1	19.2	294.81	
Red Kandhari	20.4	18.7	20.1	430	340
Red Sindhi	22.5	21.4	21.9	450	320
Sahiwal	22.4	20.9	21.7	540	326.8
Siri	21.2	19.9	—	454	363
Tharparkar	23.1	22.4	22.6	294.8	
Umbalachery	18.6	17.9		385	325
Vechur	11.2	10.2	10.6	178.43	132.0

Table 6. Reproduction performance of various breeds of cattle.

Breed	Age at first calving (days)	No. of services/ conception	Service period (days)	Calving interval (days)
Amritmahal	1337.6 ± 115.52			577.6 ± 24.32
Bachaur	1453.24 ± 21.75	1.38 ± 0.06		487.79 ± 5.92
Dangi	1351 ± 38.6	1.65	185.6 ± 9.7	474.1 ± 10.2
Deoni	1391.0 ± 26.74		170.0 ± 7.0	447.0 ± 8.0
Gaolao	1298.9		92.52 ± 1.35	387.4
Gir	1552	3.4	219.0	516
Hallikar	1370 ± 45.6			598.9 ± 27.36
Hariana	1566.8	2.39	231.85	482.73
Kangayam	1330			498.4
Kankrej	1438.1 ± 10.95		223.7	490.0
Khillari	1427.5			450
Malvi	1432.02		178.3	419
Nagori	1440.04	1.52	172.09	460.95
Nimari	1477			482.5 ± 11.64
Ongole	1473.2		191.4 ± 6.28	500.4 ± 11.26
Punganur	1125	1.35	182.8 ± 20.15	452.4 ± 18.7
Rathi	1410.6	3.34	204.72	518.8
Red Kandhari			164.7 ± 18.03	444.15 ± 9.62
Red Sindhi	1323.7	1.99	148.0	442.9
Sahiwal	1183.4 ± 18.34	2.7 ± 0.1	175.5 ± 3.7	450.6 ± 5.56
Tharparkar	1247.31	1.88	127.52	431.00
Umblachery	1593.0 ± 12.2		177.0 ± 3.0	446.0 ± 4.0
Vechur	1073 ± 46.4			449.7 ± 4.6

Market details

No well organised marketing system for beef exists in India.

Constraints to production

The major constraint for beef production in India is the legal ban on the slaughter of cows.

Buffalo Population

Basic statistics

Number by breed

There are 10 well-defined breeds of buffalo in India. However, individual breed populations are not known because the 5-yearly census considers species and not breeds. Buffalo populations in different census years are given in Table 1.

Native vs. exotic

All the buffalo breeds are native to India as they have their origin and home tract in the country. No exotic breed has been imported into India because of the availability of best buffalo germplasm in India.

The number of farms per breed of buffalo in India is given in Table 7.

Table 7. Number of farms per breed of buffalo in India.

Breed	No. of farms
Bhadawari	1
Jaffarabadi	1
Mehsana	3
Murrah	33
Nili-Ravi	1
Surti	4

Crossbred vs. purebred

Since the best buffalo germplasm is available in India, no breed/germplasm of this species has been introduced from outside for crossbreeding. However, upgrading of low producing breeds/non-descript is being carried out with improved breeds like Murrah and Surti.

Buffalo population trend

The population trend for buffalo is given in Table 4.

Production statistics

Meat production in 1998 was 1,380,000 tonnes, 1,410,360 tonnes in 1999 and 1,421,400 tonnes in 2000. Milk production in 1998 was 35.85 million tonnes, 38.0 million tonnes in 1999 and 39.0 million tonnes in 2000.

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Table 8. Birth weight and adult body weight for different breeds of buffalo.

Breed	Birth weight			Adult weight	
	Male	Female	Overall	Male	Female
Bhadawari	27.0	25.0	25.3	475	425.7
Mehsana	29.5	28.5	29.0	565.4	484.2
Murrah	31.7	30.0	30.3	567	516
Nagpuri	29.0	28.1	28.6	520	363.5
Nili-Ravi	35.1	34.5	34.8	567	454
Pandharpuri	28.0	25.6	26.8		416.2
Surti	26.3	24.5	25.2	500	382.6
Toda	27.9	28.0	27.9	380	380

Main use

The buffalo breeds in India are mainly riverine type and are used for production of milk. The buffalo males in certain regions are used for draught purposes. The male calves in the urban and rural areas are generally neglected and are starved to death. These male calves can be salvaged and used for production of meat. Further, there is a constant drain of she-buffalo from breeding tracts to urban milking centres where after completion of lactation, they are sold for slaughter at very low prices. The slaughtered buffalo reach the hands of meat traders to meet the domestic and export requirements.

Productivity information

Information on birth weight and adult body weight for different breeds of buffalo is given in Table 8.

The reproduction performance of various breeds of buffaloes is given in Table 9.

Table 9. Reproduction performance of various breeds of buffalo.

Breed	Age at first calving (days)	No. of services/ conception	Service period (days)	Calving interval (days)
Bhadawari	1477		179	478
Jaffarabadi	1361	1.50	93	440
Mehsana	1265.9	1.93	161	475.5
Murrah	1319	3.93	136.3	452.9
Nagpuri	1672	1.31	115	429
Nili-Ravi	1359	2.38	202	487
Pandharpuri	1255	3.00	165	465
Surti	1692	2.81	142	534

Market details

Marketing of buffalo meat in India is still under the traditional sector and unorganised. There are mainly three methods of sale of buffalo for meat, viz. (i) private negotiations, (ii) the under-cover sales system, and (iii) the open auction system. Out of the total slaughtered cattle, around 50% are sold by private negotiations, 27% by the under-cover sales system and the remaining 23% are sold by open auction. Maximum price is received when farmers sell their buffalo beef through open auction.

Constraints to production

India can be a major exporting country for buffalo meat, if the following three major constraints are removed.

1. The existing slaughterhouses are not sufficient in number. There is a need to construct additional slaughterhouses in areas where large buffalo populations are concentrated. This will increase export processing capabilities.
2. Some slaughterhouses in northern India cater exclusively to the export meat trade through second shift operations with every care being taken to maintain hygiene and veterinary public health inspection standards. Even then, some of the importers express doubt about the operational hygiene and handling of the system. This can be avoided when new slaughterhouses are built.
3. The animal disease situation, particularly with respect to Rinderpest and Foot and Mouth diseases, is also a major constraint in exporting meat to countries free from these diseases. If we can create zones free of these diseases, perhaps the export could be improved to a very large extent.

Genetics and Breeding Programs for Cattle and Buffalo

Out of the total cattle and buffalo available in India, the majority of the animals (>90%) are maintained

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by farmers in numbers ranging between 1 and 3, and only a few progressive farmers maintain large herds. A small fraction of the animals are available at the organised farms run by the state/central government and NGOs which maintain history sheets and record production (milk production, lactation length, dry period) and reproduction traits (service period, age at first calving, gestation period, calving interval etc.).

As regards breeding policy of cattle, most of the state governments are resorting to cross-breeding with the semen of exotic breeds like Holstein Friesian, Brown Swiss and Jersey. Holstein Friesian is the breed of choice. However, in hilly and heavy rainfall areas, Jersey has been recommended.

The semen of the exotic breeds is the source of new genetics. For superior indigenous breeds, selective breeding has been recommended but certain state governments are not following this assiduously and crossbreeding with the semen of exotic breeds is being practiced using the females of indigenous purebreds.

Progeny testing programs for selection of genetically superior bulls of some of the important indigenous breeds is going on at certain farms individually or in association with other farms maintaining the same breed. Upgrading of non-descript with superior indigenous breeds has also been recommended where feed and fodder availability is moderate, and crossbreds and exotic breeds requiring higher inputs cannot be sustained.

In buffalo, the recommended breeding policy for defined breeds of buffalo is selective breeding. For non-descript, upgrading with superior indigenous breeds has been recommended. No semen/bulls are imported from other countries as India has the best buffalo germplasm in the world.

Genetic Conservation of Cattle and Buffalo

Survey, characterisation, conservation and improvement programs for various indigenous breeds have been taken up under the Network Project on Animal Genetic Resources and NATP on Animal Genetic Resource Biodiversity at various centres located in the breeding tract of the various breeds. The programs are being run at these centers in collaboration with state agricultural universities, ICIAR institutes, state governments and non-government organisations. The objective of this program is to determine population status, socio-economic conditions and breed characteristics and to undertake a conservation program for breeds whose number is on the decline. The conservation program includes in-situ conservation by having live animal herds and ex-situ conservation by cryo-preservation of semen to conserve the threatened breeds.

Specific programs for the breeds facing extinction have been taken under various schemes as detailed in Table 10.

Table 10. Specific programs for the breeds facing extinction.

Species	Breed	Preservation and improvement programme
Cattle	Punganur	APAU, Palamner (Andhra Pradesh)
	Vechur	KAU, Mannuthy (Kerala)
Buffalo	Toda	TNVASU (Tamil Nadu)

To conclude, cattle and buffalo husbandry in India is a multi-purpose system in which these animals are used mainly for milk, draught and organic manure (dung) purposes. When there is no utility on any of these accounts or there is no profitability and animals become a burden on the farmer, these culled and spent animals are used for meat purposes.

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Development Strategies for Genetic Evaluation of Beef Production in Indonesia

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Abstract

In order to develop the livestock industry in Indonesia, global threats should be matched to the existing potential of domestic resources. Breeding and breed improvement technologies are important components in getting better valued livestock products of national and international benefit. Development plans therefore should increase added value of the product through maintaining good coordination between concerned parties in developing the livestock industry within an integrated approach, both vertical and horizontal, based on zero waste schemes. Utilisation of external input should be limited following the Low External Input Sustainable Agriculture (LEISA) approach to obtain high efficiency and competitive capacity.

TAKING into account the available local resources, many challenges and opportunities are open for developing the beef industry in Indonesia that obviously relate to biophysical, technical, socioeconomic, infrastructure and national interest factors, and in addition, anticipated internal and external changes.

In Indonesia, the beef industry is dominated by smallholder farms (with only several large-scale cattle operations around urban areas) having an average farm size of around 2–4 head/farm that are concentrated on the Island of Java. The possibility of utilising local feed resources in many instances determines the development of the beef industry, such as the abundance of agricultural residues and agro-industrial by-products that are currently not fully utilised in many regions

Indonesia as an archipelago consists of over 17,000 islands of which five are the main large islands, i.e. Sumatera, Java, Kalimantan, Sulawesi and Irian Jaya. Population density between islands varies and Java is inhabited by close to 60% of the over 200 million people (Table 1).

The country is divided into 30 provinces with variable agro-ecology zones between islands. Java has vast rice production areas, whereas Sumatera is occupied by large estate crop areas, and in Sulawesi, aside from estate crop areas, vast open grasslands are also found in the Province of South Sulawesi.

The Island of Kalimantan is still occupied by virgin forest and transport means between places is often served by boats, particularly in the swampy areas. In these areas, buffalo play an important role, as only these animals survive the rather specific ecosystem. In Irian Jaya, the infrastructure is also still limited within vast virgin forest areas. The major cattle population provinces are Java (Central and East Java Provinces), Bali, Nusa Tenggara islands, South Sulawesi and Lampung, whereas more buffalo are found on the Island of Sumatera. It is a fact that the animals are raised by smallholder farmers, thus in planning strategic approaches for agricultural development in Indonesia, one should apparently follow the Agro-ecological Potential Analysis (APA), as well as the economical, and take advantage of the potential natural resources available. It is important to take into consideration the animal density, local market, infrastructure and human resources (Ashari 1999).

Livestock Production

In the early 1990s, the beef industry in Indonesia grew very fast from initially only 5 feedlots in 1992 to 42 in 1997. The fast growth was supported by importation of feeder cattle (including products) because domestic beef production could not meet the increasing demand (Table 2).

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Table 1. Human and livestock population in Indonesia (1998).

No.	Island	Land Area (km^2)	Human (1000)	Beef cattle (hd)	Buffalo (hd)	Dairy cattle (hd)
1	SUMATERA	482,393	43,209	2,704,119	1,304,854	7,426
2	JAVA	127,499	119,631	4,823,735	703,652	314,159
3	KALIMANTAN	547,891	11,176	401,007	65,039	190
4	SULAWESI	191,800	14,519	1,684,575	271,444	56
5	IRIAN JAYA	421,981	2,111	74,942	1,534	70
6	OTHER	165,615	13,747	1,945,498	482,768	91
7	INDONESIA	1,937,179	204,393	11,633,876	2,829,291	321,992

Source: Statistik Indonesia. Biro Pusat Statistik. 1999 and Buku Statistik Peternakan, Ditjen Peternakan, 1999.

It is apparent that the monetary crisis in 1997 had a large impact on livestock development and is still affective to date with the closing of many beef cattle fattening operations. Many feedlots went bankrupt and face a huge loan burden, but currently, although the rupiah exchange rate is still weak, beef fattening operations are starting to grow again and importation of frozen meat is also slowly gaining and taking advantage of the widening supply-demand gap (Table 2).

One would not be surprised that, provided the national economy situation improves, increased population and nutrition awareness of the people would consequently increase the demand for beef as experienced in other countries. A target for Indonesia to increase beef consumption of one kilogram per capita per year would mean an additional supply of at least 1 million head of cattle and buffalo being slaughtered for the more than 200 million people.

Table 2. Meat production and consumption.

No.	Year	Meat production (000 tonne)	Meat consumption (kg/cap/year)
1	1975	435.0	3.34
2	1980	570.8	3.92
3	1985	808.4	4.95
4	1990	1027.7	5.70
5	1995	1508.2	7.90
6	1998	1228.5	4.24

Beef Cattle Production

The known local breeds of cattle of Indonesia are the (1) Bali Cattle, (2) Sumba Ongole cattle, (3) Ongole Cross cattle, (4) Madura cattle, (5) Aceh and (6) Hissar cattle (imported from India in 1909). The population in the different regions varies widely (see Table 3) and their performance has not been fully observed (see Table 4).

The local breeds of cattle in Indonesia are probably the most superior genetic resources, particularly the Bali cattle, having excellent fertility and calf–crop performance under harsh conditions. One factor that was not wanted of the Bali cattle is its low resistance against Malignant Catharral Fever (MCF), hence, it is generally not recommended to raise sheep in Bali cattle regions.

It has long been recognised that the genetic quality of the present Bali cattle is degrading due to mismanagement of the bulls and limited serious efforts for genetic improvement, and in NTT, the Bali cattle may have suffered an inbreeding problem.

The Madura cattle was believed to be a cross between the Bali cattle and Zebu over decades ago that developed well on the Island of Madura. The people of Madura have a traditional culture which includes cattle racing. In this, Madura cattle appear to be dominant.

The Sumba Ongole cattle breed originates from the Ongole cattle imported from India in 1912, and initially aimed at providing draught animal power. Their crosses with the local cattle are widely spread all over Indonesia, especially in Java (crosses between the Ongole and Javanese cattle and generally named sapi PO, known as the Peranakan Ongole or Ongole Cross cattle). The pure breed Ongole cattle are kept to date in isolation on Sumba Island, serving as a genetic resource pool. The Pesisir cattle are found mainly in West Sumatera, where the male animals are believed unsuited for draught use. The Aceh cattle is believed to be descended from the Bengal cattle of India. However, its exact breeding is not known.

The performance of the local genetic resources of cattle raised in Indonesia under different environmental conditions is shown in Table 4.

Over the years, to increase meat production through raising more productive animals by farmers, artificial insemination (AI) was implemented with

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the support of AI centres producing frozen semen in Lembang, West Java and Singosari, East Java.

Many breeds have been introduced into Indonesia, i.e. Simmental, Limousin, Angus, Brahman and their crosses are favored by farmers. Crosses of Brangus (Brahman-Angus) are foreseen to increase meat production through producing larger animals with better daily gains and for dual purpose animals (meat and milk). The official numbers do not indicate precise distribution of the different cattle breed populations in Indonesia, but certain islands have been kept isolated for a certain breed and the law closed entrance of other breeds into the island. For example, it is forbidden to introduce other breeds of cattle to Bali, Sumba and Madura islands. These islands therefore could be considered as pure genetic resource regions of local cattle breeds (Bali cattle, Sumba cattle and Madura cattle) of Indonesia. The cross breeds with overseas breeds through AI generally enter the market and are slaughtered for meat production.

Dairy Cattle Production

Apart from cattle breeds for meat production, the dairy cattle breed, the Friesian Holstein (FH), in the upland areas is also a significant meat producer, apart from milk. Pure breeding schemes have been practiced over the years to gain better milk producing animals through AI with frozen semen produced by the AI centres. These AI centres obtain semen from imported animals which are raised under good environmental conditions. A large proportion of the FH population is female, mainly kept for milk production, while the FH male calves enter the fattening

Table 3. Cattle population by province in Indonesia 1995–1999.

No.	Province	1995	1996	1997	1998	1999
1	DI—ACEH	598,754	635,460	680,027	692,538	704,796
2	N.—SUMATERA	250,569	259,314	268,364	246,279	256,967
3	W.—SUMATERA	410,644	414,406	415,252	420,688	426,173
4	RIAU	121,281	129,420	135,253	141,907	148,889
5	JAMBI	132,864	143,042	151,108	156,350	162,666
6	S.—SUMATERA	447,623	515,509	515,539	522,090	548194
7	BENGKULU	93,352	93,774	94,522	81,223	69,795
8	LAMPUNG	461,971	521,565	451,913	443,044	448,582
	SUMATERA					
	DKI—JAKARTA	0	0	0	0	0
9	W.—JAVA	195,861	214,796	183,286	151,543	151,553
10	C.—JAVA	1,253,032	1,259,948	1,260,278	1,247,995	1,291,252
11	DI—YOGYAKARTA	195,515	196,663	197,428	201,142	201200
12	E.—JAVA	3,302,426	3,339,260	3,382,670	3,223,055	3,408,823
	JAVA					
13	W.—KALIMANTAN	149,665	154,130	163,295	166,838	177,858
14	C.—KALIMANTAN	48,010	48,430	48,282	49,790	56,286
15	S.—KALIMANTAN	158,941	166,597	166,597	143,922	146,967
16	E.—KALIMANTAN	80,728	82,558	84,733	40,457	41,468
	KALIMANTAN					
17	N.—SULAWESI	271,662	282,738	294,666	294,666	304,566
18	C.—SULAWESI	273,440	250,367	262,027	273,818	286,140
19	S.—SULAWESI	805,868	827,554	840,642	823,245	864,886
20	SE—SULAWESI	265,255	276,794	289,143	292,846	295,780
	SULAWESI					
21	IRIAN JAYA	62,567	65,011	69,800	74,942	80,462
22	BALI	513,672	528,398	538,753	524,615	535,107
23	NTB	432,706	450,142	471,847	429,847	440,593
24	NTT	785,115	717,422	717,111	715,704	813,199
25	MALUKU	98,135	105,459	109,835	114,228	118,149
	INDONESIA	**11,534,066**	**11,815,606**	**11,938,856**	**11,633,876**	**12,102,500**

Source: Buku Statistik Peternakan, 1999.

operation schemes for meat production. It has been proposed to increase the population of milking animals gaining side products of male animals for meat production. The population of dairy cattle in Indonesia reached around 380,000 head with a milk production capacity of around 10 L/d collected. However, Indonesia still has to import 60–70% of the demand (1.5–2 times production capacity) milk products from overseas (Table 5).

Based on the fact that dairy cattle can be raised in lowland areas, there is a chance to develop a dual purpose cattle in Indonesia of medium production capacity, considering the low input conditions to produce milk of 7–9 L/day. The Grati cattle, which is a cross between the local cattle and Friesian Holstein, had survived in the lowland regions (Pasuruan, East Java), but are probably extinct as a result of grading-up and breed replacement programs through AI that

Table 4. Performance of cattle breeds in Indonesia.

No.	Criteria	BALI CATTLE				MADURA	ONGOLE		PESISIR	ACEH
		South Sulawesi	NTT/ North Sulawesi	NTB		Cattle	Sumba	Cross	Cattle	Cattle
1	Height (cm)									
	Female	113	115	115		105	124	105	109	102
	Male	113	115	115		115	127	105		116
2	Mating age (months)									
	Female	18–24	—	—		18	—	—	—	—
	Male	24–36	—	—		18	—	—	—	—
3	Reproduction performance	Timor	Bali							
	First estrus (mth)	18-24	23	—		—	—	12	—	—
	First mating (mth)	24	16	—		30	—	—	—	—
	Length of estrous (hr)	24–26	—	—		36	—	—	—	—
	Estrous cycle (d)	19±4	—	—		21	—	—	—	—
	Calving interval (mth)	—	—	—		16	—	16	—	15–18
	Calving Rate (%)	—	—	90.1		—	82.5	—	—	—
	Calf crop (%)	42	—	72–92		—	52.6	—	—	—
4	Age at first mating (months)	—	—	—		27	—	—	—	—
	Age at first calving (months)	—	—	—		36	—	—	—	—
5	Body Weight (kg) **			Natural mating	AI					
	Birth weight (kg)	—	—	15	12	—	—	—	—	—
	Weight at 1 month (kg)	—	—	—	—	—	—	—	15	—
	Weight at 6 months	—	—	119	84	—	—	—	—	—
	Weight at 12 months	—	—	226	158	—	—	—	136	—
	Weight at 18 months	—	—	323	228	—	—	—	—	—
	Weight at 24 months	—	—	380	304	—	—	—	—	—
	Weight at 36 months	—	—	—	—	350	340–355	—	—	—
	Adult weight Male	—	—	—	—	—	400	—	240	253
	Adult weight Female	—	—	—	—	—	310	—	—	148
6	ADG (kg)	—	—	0.57	0.30	—	0.25	—	—	—

Source: Simanjuntak, D.S. 1999.

Table 5. Milk production and importation.

No.	Year	Production (ton)	Consumption kg/cap/yr	Import (TON)		
				Milk	Butter	Cheese
1	1995	433,442	6.99	66,070.5	38,533.8	7911.0
2	1996	441,163	5.72	51,788.5	32,315.8	6119.4
3	1997	423,664	5.25	48,783.3	29,795.3	4691.3
4	1998	375,385	4.16	32,737.4	17,944.3	3809.9
5	1999	384,318	4.13	—	—	—

have been widely implemented with good results for dairy cattle in Java, whereas on other islands, milk appears not in demand. Buffalo milk, on the other hand, is in high demand by certain ethnic groups in North and West Sumatera. Rutlage suggested developing hybrid cattle through IVM/IVF and ET. This consequently needs further study, particularly on economic aspects. ET with beef cattle may not be feasible and not recommended while farmers and government livestock services do not see the advantage and moreover it does not fit with genetic improvement goals using biotechnology approaches.

Buffalo Production

The buffalo (*Bubalus bubalis*) in Indonesia is generally raised by smallholder farmers as an integral part of the farming systems. More important is its role as a living savings account. There are five distinctive types of buffalo found in Indonesia, namely: Swamp buffalo, widely spread, Kalang buffalo found mainly in Kalimantan, Murrah buffalo found in North Sumatera, Toraja buffalo and Anoa mainly found in Sulawesi. The major buffalo type raised in Indonesia are the local swamp buffalo, but population figures of the different buffalo types do not appear in the published figures. Statistical figures available revealed the total population and registered number of buffalo slaughtered in specific regions (Table 6), and distribution related to age and physiological stage (Table 7). The population of buffalo in Indonesia could be considered as static, if not slightly decreasing over the past decade.

Like cattle, most buffalo in Java are raised by farmers in relatively small numbers (2–3 head/farm), whereas in Kalimantan and Sumatera the number of

Table 6. Buffalo population by province in Indonesia 1995–1999 (× 1000 head).

No.	Province	1995	1996	1997	1998	1999
1	DI—ACEH	420.6	430.1	397.7	420.7	433.6
2	N.—SUMATERA	247.9	256.4	265.0	264.2	265.6
3	W.—SUMATERA	204.7	216.2	220.4	224.3	228.3
4	RIAU	45.1	49.9	55.5	56.3	57.1
5	JAMBI	81.3	85.6	86.2	85.2	85.9
6	S.—SUMATERA	127.7	150.1	149.4	152.0	155.0
7	BENGKULU	86.1	87.0	87.1	49.3	27.9
8	LAMPUNG	47.9	50.7	35.6	52.8	53.9
	SUMATERA	**3256.3**	**3322.0**	**3293.9**	**3302.8**	**3306.3**
9	DKI—JAKARTA	0.5	0.5	0.7	1.0	1.0
10	W.—JAVA	500.5	490.9	434.7	356.0	357.4
11	C.—JAVA	256.4	243.9	220.3	190.0	196.7
12	DI—YOGYAKARTA	9.7	9.3	8.7	7.2	7.3
13	E.—JAVA	156.1	160.0	153.9	149.4	149.4
	JAVA	**923.2**	**904.6**	**818.3**	**703.6**	**711.8**
14	W.—KALIMANTAN	6.6	7.3	6.4	6.5	8.1
15	C.—KALIMANTAN	9.1	12.2	9.9	9.9	10.5
16	S.—KALIMANTAN	46.5	47.6	47.6	34.1	37.3
17	E.—KALIMANTAN	22.7	23.3	24.9	14.5	14.7
	KALIMANTAN	**84.9**	**90.4**	**88.8**	**65.0**	**70.6**
18	N.—SULAWESI	0.1	0.02	0.1	0.2	0.2
19	C.—SULAWESI	13.6	9.7	8.3	7.1	7.4
20	S.—SULAWESI	336.5	340.6	342.3	252.7	257.4
21	SE—SULAWESI	11.7	10.8	11.5	11.5	11.5
	SULAWESI	**361.9**	**361.12**	**362.2**	**271.5**	**276.5**
22	BALI	11.1	11.1	11.1	9.2	9.2
23	NTB	214.4	220.5	226.5	206.4	208.4
24	NTT	191.1	164.6	167.1	162.3	164.8
25	MALUKU	21.6	22.3	23.3	24.2	24.4
26	IRIAN JAYA	0.08	0.8	1.1	1.5	2.1
	INDONESIA	**3135.5**	**3171.2**	**3064.5**	**2829.3**	**2775.1**

animals per farm may reach 100. In the eastern part of Indonesia, i.e. Nusatenggara islands, open grasslands are available as communal grazing lands. Efforts to improve the production and quality of communal pastures becomes almost impossible with the relative lack of pasture management resources as no one will be responsible for maintaining the improved pastures. In North Sumatera, large plantation areas dominate the region. However, livestock are still considered a pest.

Table 7. Distribution of buffalo by age (%).

	Male	Female	Total
Weaning	9.03	9.88	18.91
Yearling	10.34	15.13	25.47
Mature	11.93	43.69	55.62
Total	31.30	68.70	100.00

Source: Agricultural Census (CBS) 1993.

Special values of the buffalo in particular regions include:

- production of meat and milk as a nutritious food;
- skin including horn, bones and hooves for home industry work;
- source of draught animal power;
- transport of agricultural products;
- engine to run the wheels in sugar and rice mills;
- symbol of cultural beliefs;
- buffalo racing.

Potential for Breed Improvement

Over the past two decades, meat prices have fluctuated relatively little with the tendency to increase steadily over the years and the current market price of local live animals reached Rp 12–Rp. 13/kg bodyweight (= US$1.20–1.30/kg bodyweight) while imported cattle are sold at US$0.9/kg bodyweight. It is apparent that the market of livestock products is not a problem as with other agriculture food commodities and fish.

One recent policy of the government in 1998–1999 to keep meat price down by importing cheap meat (coupled with animal health problems) has in fact created a market distortion. In addition, the situation was unwisely utilised by opportunistic market agents, as situation that resulted in excessive slaughtering of productive female cows; hence, the sharp decrease in the cattle population. The conduct of slaughter of productive female cows at the official abattoirs is against the law ('UU. No. 6/1967').

Following the livestock revolution trends, a rapid increase in demand of livestock products (meat and milk) in developing countries was predicted prior to the 1998 economic crisis. The medium and long-term consumption trends of milk products present an exciting opportunity for Indonesia's smallholder farmers to benefit from increased market price, as well as gaining a liquid savings account in the form of live animals. The huge market demand and lack of imported products presents a vast opportunity to enhance domestic production for meat through raising better genetic quality animals. It was considered important for farmers to gain a better price for quality animals that are in demand. For example, crossbred animals with semen of Simmental are valued at a higher price even before it is born. Apparently, increased livestock production will maintain the country's financial balance and save foreign exchange expenditure on import meat.

Development approaches generally focus on increased production efficiency towards producing value added competitive products in the national and international market. Various concepts that are to be decided upon in developing the beef and dairy cattle industries in Indonesia should adopt achievement of the following criteria:

1. Produce calves of good genetic quality through fattening operations to cover the demand and increase meat production—*food security*.
2. Increase farmers income and welfare—*poverty alleviation.*
3. Develop sustainable livestock industry without negative impacts on the environment—*sustainable environment*.

Breed development operations require breeding centres and, particularly for dairy cattle, the Indonesian Dairy Cooperative Union (Gabungan Pengusaha Susu Indonesia—GKSI) in collaboration with the government livestock services was expected to rear the selected dairy calves produced for breeding stock. The government has 11 UPTs (Livestock Breeding Units) consisting of 8 institutes for Animal Breeding and Forages (BPT-HMT), 2 artificial insemination centres (BIB) in Lembang and Singosari and one Embryo Transfer Institute (BET) at Gunung Sindur, West Java. The production capacity of frozen semen of the AI centres in 1999 showed more beef cattle than buffalo and around 51,000 doses for dairy cattle (Table 8) being produced to meet the demand. Further, the development of Village Breeding Centres have been under consideration and private enterprises are also encouraged to develop breeding units which at present only focus on poultry, pigs and race-horses. Following FAO recommendations on the status of genetic resource conservation, none of the cattle and buffalo breeds of Indonesia are under endangered conditions.

Table 8. Production of frozen semen at AI centres (1998/1999).

Type	Breed	Lembang	Singosari	Total
Dairy	FH	28,026	23,797	51,823
Beef cattle		1,040,813	328,139	1,368,952
	Bali	0	37,584	37,584
	Madura	0	5,001	5,001
	Ongole	219,829	69,809	289,638
	Brahman	502,929	167,030	669,959
	Simmental	184,884	9,568	194,459
	Limousine	13,416	39,147	52,563
	Brangus	119,755	0	119,755
Buffalo		8,209	0	8,209
	Murrah	7,958	0	7,958
	Spotted	251	0	251

Limitations

Importation of proven bulls and frozen semen may continue. However, the major question that remains unanswered is the direction of beef cattle breeding policy. Continued importation of proven bulls (and semen) will apparently bear the risk of local genetic resource erosion and potential genetic interference problems. It appears that the development of Village Breeding Centres may be most feasible; however, there is the need for a sustainable production system for farmers who would be required to continue record keeping.

The distribution of cattle in Indonesia (Table 3) shows that the number of animals is closely related to the distribution of the human population. In the

Table 9. Artificial insemination program for cattle (1997).

No	PROVINCE	Target (Dose)	Realisation (dose)	Birth (heads)
1	DI—ACEH	56,300	34,635	9,829
2	N.—SUMATERA	43,000	27,681	7,507
3	W.—SUMATERA	43,000	28,598	8,300
4	RIAU	17,950	4,428	830
5	JAMBI	19,900	14,611	4,241
6	S.—SUMATERA	75,000	45,264	8,576
7	BENGKULU	14,500	8,876	1,369
8	LAMPUNG	47,000	37,865	10,605
9	DKI—JAKARTA	0	0	0
10	W.—JAVA	48,400	47,044	8,014
11	C.—JAVA	418,000	365,476	164,750
12	DI—YOGYAKARTA	59,500	53,585	7,974
13	E.—JAVA	695,750	629,902	238,094
14	W.—KALIMANTAN	5,250	2,299	392
15	C.—KALIMANTAN	5,000	3,251	489
16	S.—KALIMANTAN	16,800	16,556	5,376
17	E.—KALIMANTAN	15,500	0	0
18	N.—SULAWESI	15,000	5,212	0
19	C.—SULAWESI	35,000	14,923	700
20	S.—SULAWESI	78,000	39,083	5,281
21	SE—SULAWESI	6,500	6,190	300
22	BALI	40,000	40,549	4,594
23	NTB	13,000	52,423	15,439
24	NTT	5,000	5,779	889
25	MALUKU	1,000	2,152	0
26	IRIAN JAYA	9,000	0	0
	INDONESIA	**1,856,350**	**1,487,087**	**503,684**

agrarian situation, this condition could be considered as a consequence of the efforts of farmers when the development of cattle and buffalo was primarily aimed at the provision of draught animal power and savings. The green revolution that started in the 1970s introduced the use of tractors/farm machinery and chemical fertilisers and left cattle behind. Under the present situation, the creation of on-farm jobs would hopefully make farmers raise cattle.

Raising of cattle as an economic enterprise is not feasible, as judged from the investment, interest rate, technical coefficient, and market value of the calves. However, smallholder farmers are still willing to raise cattle. Grazing is generally not practiced due to (a) the high value of land, (b) livestock safety problems (i.e. in S. Sulawesi, NTB), and (c) non-feasible resources like the upland areas. In the late 1970s, there were some cattle ranch operations in South Sulawesi, Lampung, West Java, NTT, South Kalimantan, South Sulawesi; however, these do not exist anymore and went bankrupt, except for one in South Sulawesi that maintains its operation with government support. Communal grazing areas are also getting smaller because of other land use purposes.

The integrated agricultural systems (crop and animal) have been applied by the Great Giant Pineapple Ranch in Lampung, Oil Palm Estate Plantation in Riau, Sugar Cane Industries in Java and South Sulawesi, and some farmers in Central Java. The key to success is the release from a fundamental problem with reference to limited physico-chemical status of land resources that need the support of organic fertiliser. The use of compost material of a large industrial exercise has increased land productivity and also reduced costs of crop production; hence, increased farm income. Farmers have justified and are willing to apply and use the processed organic compost that also opens a new organic agriculture market.

The main reasons that agriculture and agro-industry by-products and residues are not utilised well are: (a) its voluminous nature and presence of anti nutritive factors, (b) lack of sub-sector policies and related infrastructure, (c) partial economic analysis and technology transfer that are not conducive. Experience of improper selection of the breeding stock and technology application has hampered the progress in expanding/developing livestock production in Indonesia. When genetic improvement policy and breed selection are not properly done, it may not meet the macro- and micro-environment pre-requisites. Breed improvement technology schemes are generally set to meet high input management; hence, they are not economically nor socio-culturally feasible.

Conclusion

For the success of developing the livestock industry in Indonesia, one should match the global threats and existing potential of domestic resources. Breeding and breed improvement technologies are important components in getting better valued livestock products of national and international benefit. Development plans therefore should increase added value of the product through maintaining good coordination between concerned parties in developing the livestock industry within an integrated approach, both vertical and horizontal, based on zero waste schemes. Utilisation of external input should be limited following the Low External Input Sustainable Agriculture (LEISA) approach to obtain high efficiency and competitive capacity.

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Country Report: Lao PDR

Akhane Phomsouvanh[1]

Abstract

Livestock, particularly cattle and buffalo, are widely produced and are the main source of cash income for smallholders. The annual growth rate is about 4%. Livestock not only provide a source of protein but also draught power, manure as fertiliser, and bank savings. Livestock are traditionally part of subsistence agriculture, complementary with and supplementary to crop production. Buffalo and cattle are the most important economic animals, not only because of their use for draught power and as a resource of animal protein, but also because they represent an increasingly important exportable product and a source of foreign exchange earnings.

LAO PDR is a landlocked country with a total land area of 23.68 million hectares (236,800 km^2). About 75–80% of the land area is hilly and mountainous and about 20% is lowland. Forests cover 47% of the total land area. The estimates for the total area suitable for grazing range from 2 to 8.1 million hectares.

The Lao population is about 5.2 million (in 2000) and the overall population density is about 22 persons per km^2. Average family size is 6.5 persons. This figure has been reducing recently due to effective family planning. More than 83% of the total population are in rural areas and 66% of these are living off subsistence agriculture.

Agriculture is the most important economic sector in Lao PDR. It accounts for more than half the country's GDP, about 40% of its official export earnings and is the main source of income for about 85% of the population. Output of the sector has been increasing but both growth and foreign investment is well below the manufacturing and services sectors of the economy.

Livestock, particularly cattle and buffalo, are widely produced and are the main source of cash income for smallholders. The annual growth rate is about 4%. Livestock not only provide a source of protein but also draught power, manure as fertiliser, and bank savings as well. It is noted that the actual animal protein intake of the population is quite low at 11% of the total daily intake. Table 1 shows current meat consumption. It is, of course, the intention that meat consumption should increase.

Table 1. Estimated present consumption of meat (Unit: kg/person/year).

Item	Meat consumption urban area	Meat consumption rural area
Beef	3–4	1–2
Buffalo meat	2–3	1–2
Pork	7–8	5–6
Poultry	8–10	4
Fish	8–10	8
Total	33	22

Cattle Population

The cattle populations for the past three years are shown in Table 2.

Table 2. Cattle population (1998–2000) (Unit: 1000 head).

Year	Number of cattle
1998	1216
1999	1000
2000	1100

Source: Department of Livestock and Fisheries, MAF, 2000.

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In order to supply the increasing demand for livestock products and to improve cash earnings from exports, livestock is to be boosted in a much more commercialised way, moving away from nature-dependent subsistence farming to full-scale commodity production.

The structure of the cattle herd in Lao PDR is shown in Table 3.

Table 3. The structure of the cattle herd in Lao PDR.

Item	Number of animals
Total male population	528,000
Total female population	572,000
Male with >3 year old	248,100
Female with >3 year old	268,800
Male 2–3 year old	137,100
Female 2–3 year old	148,600
Male 1–2 year old	73,200
Female 1–2 year old	75,800
Male 1 year old	70,400
Female 1 year old	78,800
Total	1,100,000

Source: Anon. 2000b.

Cattle production data for the past three years is shown in Table 4.

Table 4. Cattle production for the past 3 years (Unit: tonnes).

Item	1998	1999	2000
Meats production	27,360	22,500	24,750

Source: Anon 2000a.

The average calving interval is one year (Table 5). Pre-weaning death loss is estimated to be as high as 10–15%, but post- weaning death loss is usually low (2–3%). Age of cows at first calving ranges from 4 to 5 years, which indicates that their age at first breeding is around 3 to 4 years.

Cattle calves at birth weigh around 20 to 25 kg and at weaning (8 months) 70 to 90 kg. The post-weaning gain ranges between 0.24 to 0.30 kg per day when they are fed mainly on grass. If they are raised on improved pasture with reasonable supplements, they could gain 0.50 kg per day. The weight of cows averages 150 to 200 kg while mature castrated males average 250 to 300 kg.

In the Lao PDR, currently more than 99% of the cattle are indigenous or Yellow Asia. The local cattle are small in size, more tolerant to diseases, and can make good use of roughage. The cattle production system is based on the smallholders' traditional system. Management is minimal with no feed supplementation. There has been neither deliberate selection nor mating control.

Table 5. Production characteristics of cattle in Lao PDR.

Item	Unit	Coefficient
Calving interval	Yr	1
Death loss (weaned calves and older)	%	2–3
Death loss (birth to weaning)	%	10–15
Weight at birth	Kg	20–25
Weight at weaning (8 months)	Kg	70–90
Weight of cows	Kg	150–200
Weight of bullocks at maturity	Kg	250–300
Age at first calving	Yr	4–5
Post weaning daily gain, grass	Kg	0.24–0.30

Source: Anon. 2000a.

Genetic improvement of cattle should be promoted through selection of the elite male of the existing herd to be used as the bull. Undesirable males should be castrated. Details are clearly stated in the government provision on the control of livestock in Lao PDR (Anon. 1999). Therefore, the policy for cattle can be formulated referring to the specifics of the farming system and the socio-economic status of the farmers in different areas as follows:

Lowlands

In the near future, there will be no longer any free ranching in the lowland areas where intensive crop production is being promoted. Farmers will have to keep their cattle in their yards, or fenced pastures. Cattle production in the lowland areas will be changed from traditional methods of animal husbandry to the promotion of different levels of intensive cattle farming systems such as:

1. Individual animal-keeping with feed supplements;
2. Small-scale cattle farms within fenced areas;
3. Cattle farms;
4. Cattle feedlots;
5. Cattle/buffalo breeding farms.

Indigenous cattle might not be suitable for such exploitation because of their low performance.

In the lowland areas, particularly irrigated rice-production areas and suburban areas, a crossbreeding program will be used for long term strategies to produce crossbreed animals for feedlot. The crossbreeding program will be carefully developed with concrete objectives, goals and targets. This needs experienced professional people to help map out the program.

However, improvement of the native breed with exotic breeds, especially for cattle, should also be

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taken into account, particularly in the lowland areas where farmers know how to take good care of their animals with feed supply, health care and management etc. In addition, the Holstein-Friesian dairy cows at Nabong Farm and the Brahman crossbreed at Namsouang Station could be used as demonstration animals for other farmers who decide to run an animal farm.

In the past, breeding practices mostly have depended on natural mating in free range situations without selection or breeding controls. However, the practice now is little used because of low productivity associated with inbreeding.

Artificial insemination (AI) now is quite well known among producers. Some producers tried to use the AI method on their cows, e.g. the livestock sector of Vientiane Prefecture and some farms such as Latsen and Nabong cattle farm, used to practice AI techniques with simple equipment. In the future, we are looking for technical and financial support to establish an AI unit and to utilise these techniques to accelerate breed improvement.

Uplands

At present, the population density of cattle in upland areas is relatively low or less than 20% of the total herd. Therefore, extensive cattle production will be promoted with different levels of production (cattle-raising among rotated shifting cultivation fields, small-scale cattle or buffalo farms) and cattle farms in some suitable areas.

Cattle production in upland areas will be promoted in accordance with government policies on the creation of permanent employment for the swidden farmers in order to reduce and eventually to eliminate swidden farming.

At present, indigenous cattle are more suitable for upland areas in the context of farmers' knowledge and know-how, existing technical support facilities, socio-economic conditions and other infrastructure. Therefore, the policies of the Department of Livestock and Fisheries for these areas will promote the production of indigenous cattle with emphasis on mass selection of the bull which shows a good phenotype and performance with daily gain over the average of the herd (Anon. 1993).

A strategy and methodology for developing in situ conservation of native cattle should take into consideration the following proposal for follow-up action:

1. Need to identify, research and develop the cattle production programs as the main component, along with pig and poultry development for upland areas with the focus on appropriate farming systems based on economic, social and ecological parameters.
2. The extension program should be focused on the transmission of the results of research to the farmers and producers through institutional strengthening, training, workshops or the publication of mass media information.

Buffalo Production

The buffalo populations for the past three years are shown in Table 6.

Table 6. Buffalo population data for the Lao PRD (Unit: 1000 head).

Year	Number of buffalo
1998	1093
1999	1008
2000	1028

Source: Anon. 2000a.

Buffalo production information for the past three years is shown in Table 7.

Table 7. Buffalo production in Lao PRD, 1998–2000 (Unit: tonnes).

Item	1998	1999	2000
Meats production	27,872	25,704	26,214

Source: Anon. 2000a.

Buffalo are mainly owned by small-scale farmers although some individual farmers may own as many as 30–50 head, particularly in the upland and remotest areas. Swamp buffalo are indigenous and make up almost 100% of the total buffalo population. Some few Murrah buffalo are found at the Namsouang cattle station. Murrah buffalo (100 cows and five bulls) were introduced to Laos in 1976 from India as a gift for the first ever president, Chao Souphanouvong. The popularity of this kind of buffalo is poor. Thus, the plight of this beast is unknown. The actual Murrah population at Namsouang cattle station is around 30.

Buffalo are extensively grazed and not given feed supplements or housing. In lowland areas where dry paddy is produced, buffalo are kept and fed with volunteer grass and rice straw along the paddy field. Mating is through natural means. So far, there is no intention to use AI. Buffalo meat is still popular, even more so in the northern part of the country. Data on buffalo production in Laos are very scarce.

The structure of the buffalo herd in Lao PDR is shown in Table 8.

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Table 8. The structure of buffalo herd in Lao PDR.

Item	Number of animals
Total male population	534,500
Total female population	493,500
Male with >3 year old	270,600
Female with >3 year old	271,400
Male 2–3 year old	160,300
Female 2–3 year old	148,000
Male 1–2 year old	62,100
Female 1–2 year old	48,000
Male 1 year old	41,500
Female 1 year old	26,100
Total	1,028,000

Source: Anon. 2000B.

It was mentioned above that swamp buffalo in Laos make up almost 100% of the total population. Two colors of the skin, gray black and white, have been found. Buffalo are able to thrive under adverse conditions, utilise poor quality fodder, grow relatively rapidly and produce a heavier carcass than that of cattle. Poor reproductive rates have, however, restricted their exploitation for commercial beef production purposes. The age at first calving is around 4 to 5 years old, depending on local feed resources and the quality available in the region.

The average calving interval is one and a half years (Table 9). Pre- weaning death loss is estimated to be as high as 15–20%, but post-weaning death loss is usually low (3–5%). Age of buffalo cows at first calving ranges from 4.5 to 5.5 years, which indicates that their age at first breeding is around 3.5 to 4.5 years.

Buffalo calves at birth weigh around 24 to 32 kg and at weaning (8 months) 90 to 120 kg. The post-weaning gain ranges between 0.24 and 0.30 kg per day when they are fed mainly on grass. If they are raised on improved pasture with reasonable supplements, they could gain 0.50 kg per day. The weight of buffalo cows averages 250 to 340 kg while mature castrated males average 300 to 400 kg.

Production characteristics of buffalo in Lao PDR are shown in Table 9.

With regard to livestock marketing for cattle and buffalo, markets are available everywhere, at any time, even in the villages. A marketing system is practiced among livestock owners and buyers which depends on both sides agreeing to buy or sell, then the sales take place.

Table 9. Production characteristics of buffalo in Lao PDR.

Item	Unit	Coefficient
Calving interval	Yr	1.5
Death loss (weaned calves and older)	%	3–5
Death loss (birth to weaning)	%	15–20
Weight at birth	Kg	24–32
Weight at weaning (8 months)	Kg	90–120
Weight of cows	Kg	250–340
Weight of bullocks at maturity	Kg	300–400
Age at first calving	Yr	4.50–5.50
Post weaning daily gain, grass	Kg	0.24–0.30

Source: Anon 2000a.

Livestock in the Lao PDR are traditionally part of subsistence agriculture, complementary with and supplementary to crop production. Buffalo and cattle are the most important economic animals, not only because of their use for draught power and as a resource of animal protein, but also because they represent an increasingly important exportable product and a source of foreign exchange earnings.

Genetic Conservation of Cattle and Buffalo

Livestock can be improved by utilising the available merits of existing stock by different breeding programs while maintaining biodiversity. Livestock productivity can be improved through the improvement of animal husbandry management (feed and feeding, animal health care, etc.) and improved breeding though selection. The fusion of exotic blood into the indigenous herd will also be taken into account for specific zones and market potential. Maintaining biodiversity of the animal genetic potential of the country is required. The main question is how to promote the production of a breed that is suitable for the farmers and accepted by the farmers in different agro-ecological zones or farming systems.

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Breeding for Beef Production in Malaysia

M. Ariff Omar[1]

Abstract

The Malaysian beef industry relies on small populations of local Kedah-Kelantan and crosses of the local cattle with imported breeds such as Brahman, Hereford, Limousin and Friesian and buffalo of the Swamp and Murrah types. Local production contributes less than 20% of the domestic requirement for beef while the balance is satisfied through imports of frozen beef from India, and chilled beef and live animals from Australia and New Zealand. Integrating beef cattle in oil palm plantations is the recommended production system so as to capitalise on the abundant supply of feed from native grasses and the suitable environment. Genetic improvement for beef cattle and buffalo has not been seriously addressed on a national level and it is an issue worth considering for the further improvement of the beef industry.

THE MALAYSIAN economy has historically been dependent on agriculture. Throughout the rapid industrialisation phase of the country's development, agriculture has continued to play a significant role—65% of the current rice supply is produced locally while rubber, palm oil, pineapple and cocoa are being grown mainly for the export markets. However, both the economy and the population continue to expand, thus creating more demand for many food items. Constrained by a lack of essential irrigation infrastructure and marketing facilities in the major crop growing areas, attempts at fulfilling the domestic demand for food have been achieved with moderate success.

The livestock industry has contributed substantially to the supply of animal protein to the general populace of 22 million people, principally in meeting the demand for poultry meat, eggs and pork. Although the poultry and swine industries hinge vulnerably on the supply of imported feed ingredients (mainly maize and soy bean), they have prospered over the years by producing value-added poultry meat, eggs and pork. This remarkable entreprenuership has not been mirrored by the beef, goat meat and dairy industries.

The feed industry has been reponsive to the needs of the poultry and swine industry—adequate supply of livestock feed is made available at reasonable prices to producers. Feed for ruminants is still sourced from native grasses and legumes with supplementary concentrates provided strategically.

The use of modern breeds of chicken and pigs has boosted the production of chicken meat, eggs and pork. However, the ruminant sector, comprising dairy cattle, beef cattle, sheep, goats and buffalo, has experienced moderate success in growth and population expansion. Small population size, inadequate feed supply and inappropriate production systems have often been cited as the limiting factors in the further expansion of the ruminant sector.

Demand and Supply of Livestock Products

Local production for poultry meat, eggs and pork has demonstrated a strong capability in meeting the domestic demand with small surpluses for export, mainly to Singapore. In 1999, the total ex-farm value of livestock products was US$1145.2 million: US$660.3 million for poultry meat, US$262.4 million for eggs, US$148.2 million for pork, US$10.1 million for milk, US$59.7 million for beef and US$3.6 million for goat and sheep meat. Local production of chicken, egg and pork has exceeded domestic demand (Table 1) and the local poultry sector has embarked on intensifying down-stream activities to accommodate increased demand for processed products by consumers and fast food restaurants. However, the local supply of beef, goat and sheep meat and milk has not

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kept pace with domestic demand. Self-sufficiency levels for beef, milk and goat meat continue to decline over the years.

Livestock products are projected to show a trend of increasing demand in the coming decades. This could be attributed to a number of factors: rising economic affluence of the people, better purchasing power, concern for a well-balanced diet, increased knowledge in the role of animal protein in human health and higher consumption of animal proteins compared to carbohydrate sources.

The NAP3 (1998–2010) has targets of 38,700 Mt of beef being produced by 2005 and 58,600 Mt by 2010.

Current Development in Beef Genetics and Breeding

Beef cattle

The major breeds of beef cattle in this country are Kedah-Kelantan (KK), Brahman crosses and European-Kedah-Kelantan crossbred types. Crosses between the KK cattle with imported breeds such as the Brahman from India and the United States, Nellore and Indu-Brasil from Brazil and some of the European breeds such as Limousin, Charolais and Hereford have been generated through the artificial insemination program and the bull and breeder cow loan scheme managed by the Department of Veterinary Services. However, these breed upgrading initiatives have not been sustained through a systematic and long-term genetic improvement plan.

Kedah-Kelantan cattle has been reared in this country for many decades. Its purpose has shifted from ploughing the paddyland and transporting goods to supplying beef to the local market. Less than 20% of the total demand of 92,553 tonnes of beef are supplied by the domestic Kedah-Kelantan cattle. Insufficient number of breeder cows and an inefficient production system have been cited as the major reasons for the low output from the local cattle. The domain of Kedah-Kelantan cattle is in oil palm settlements of Felda, Felcra, Espek and individual ownership, rural villages and single-cropped and idle paddyland.

Breed characterisation

When considering the most effective breeding approach to undertake for efficient beef production it is important that the locally adapted breeds of cattle be fully characterised and the effects of crossing them with other world breeds of cattle be estimated. Characterisation of some of the production traits and phenotypic parameters of Kedah-Kelantan cattle has been reported by Devendra et al. (1973), Devendra and Lee (1975); Wan Zahari et al. (1977), Aman et al. (1978) and Dahlan et al. (1981).

Differences in mature weight existed among pure-bred KK and crosses of KK with Hereford, Brahman and Friesian. Crosses were heavier at maturity than KK (Table 2). The difference between the mature weight of KK and Brahman-KK cross was smaller than between KK and *Bos taurus*-KK crosses (Ariff et al. 1993).

Table 2. Mature weight and rate of maturing of straight-bred and crossbred Kedah-Kelantan cattle.

Breedtype	Mature weight (kg)	Rate of maturing
Kedah-Kelantan (KK)	227.8^{a}±2.30	0.0523 ^{a}±0.0037
Hereford-KK	333.3 ^{b}±7.86	0.0366 ^{b}±0.0029
Brahman-KK	316.5 ^{b}±4.02	0.0428 ^{c}±0.0018
Friesian-KK	320.9 ^{b}±9.43	0.0376 ^{b}±0.0034

Mean values in each column with different superscripts are different (p<.05).
Source: Ariff et al. (1993).

KK cattle has the lowest mature weight (227 kg) and the fastest maturing rate (0.0523) among the breedtypes studied. In a situation such as that found in many habitats of KK—poor quality feedstuffs and

Table 1. Production and consumption of livestock products—1999.

Commodities	Local production	Total consumption	Per capita consumption	Percent self-sufficiency
Poultry meat	690,040 mt	594,560 mt	26.2 kg	116.1
Eggs	6,710,000 eggs	6,239,000 eggs	275 eggs	107.6
Pork	158,685 mt	146,980 mt	6.5 kg	107.9
Beef	18,300 mt	92,553 mt	4.1 kg	19.8
Goat meat	893 mt	13,605 mt	0.6 kg	6.5
Milk	28.8 mil. litres	754.2 mil. litres	33.2 litres	3.8

Source: Hawari (2001).

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inconsistent supply of feeds—a small mature size (weight) would certainly have an advantage in meeting the stresses of physiological demands and maintenance from a limited nutrient supply.

Reproductive potential

The number of embryos generated by a normally cycling cow would provide an indication of the reproductive potential of a particular breed. Johari et al. (1995) were able to induce super-ovulation in 76% of the 59 KK cows after treating the cows with follicle stimulating hormone. The mean number of corpora lutea was 7.3, giving 284 potential embryos. From 39 cows that were flushed, 145 embryos were obtained, giving a yield of 3.7 embryos per donor. However 57% of the recovered embryos were found to be of poor quality for transfer to recipient cows. The poor harvest of embryos and their low quality could be associated with the incompatible hormonal regime employed.

The reproductive efficiency of Brakmas cows is generally high. The age at first calving for Brakmas heifers was 32 to 37 months. Pregnancy rate of 78% and a calving rate of 73% for a group of highly selected Brakmas cows have been reported by Johari (2001).

Breeding strategies

The integrated cattle-oil palm production system has gained widespread acceptance by the plantation sector, especially those plantations owned by settlers and government-related agencies. There are many commercial herds of Kedah-Kelantan and Brahman-crosses which have been established. MARDI proposes a nucleus breeding scheme be adopted to provide a reliable source of selected male genetic materials for distribution to the multiplier and commercial herds. A herd improvement program could be incorporated within the proposed nucleus breeding scheme.

Water buffalo

There are two types of water buffalo found in Malaysia: Swamp buffalo and River buffalo. Swamp buffalo are more predominant in terms of population size compared to River or dairy buffalo. The Swamp buffalo is a popular source of meat to many Malaysians especially in the states of Pahang, Negeri Sembilan and Sarawak (Limbang-Lawas area). With the introduction of mechanisation in rice cultivation, the role of buffalo in ploughing the paddyland has diminished. As a consequence, the Swamp buffalo has been neglected without any systematic programs to breed and conserve them.

Cytogenetic evaluation

There are 48 chromosomes in the chromosomal make-up of Swamp buffalo and the River buffalo has 50 chromosomes (Bongso, 1986). Chromosomal polymorphism has been observed in the F_2, generated from the mating of F_1 and F_1 crosses, producing three chromosomal genotypes of 48, 49 and 50 (Harisah, 1988). Further upgrading through backcrossing of the F_1 to either the Swamp (48) or River (50) parents has resulted in genotypes with 48 and 49 or 49 and 50 chromosomes, respectively. Unbalanced gametes with multivalent configurations have been linked to a reduction in fertility in *Bos taurus* bulls carrying 59 chromosomes (Gustavsson, 1980). Ramakrishnan et al. (1989) reported a low sperm motility and a higher incidence of sperm abnormalities in crossbred buffalo with 49 chromosomes.

Breeding strategies

Much less can be described on the breeding strategies of buffalo in this country. While buffalo remains a valuable source of meat, supplementing the national beef supply, the absence of any developmental approach to improve and expand the buffalo population has reduced the species to survive on its own. Small populations of Swamp buffalo can still be located in villages close to idle paddyland, river banks and rural villages.

The Swamp buffalo has not been fully exploited for meat production. An attempt to collect unattended buffalo belonging to villagers in the district of Rembau in Negeri Sembilan and managed them in small herds for group mating has met with little success. With the current population of 88,163 head in Peninsular Malaysia and 12,000 head in Sarawak and 50,000 head in Sabah, Swamp buffalo provide a rich genetic resource for economic exploitation. The benefit resulting from the crossbreeding of the Swamp and River buffalo expressed as a 5 to 20% hybrid vigour in body weight gain would not merit such an exercise because of the possibility of fertility impairment in some of the crosses. It would facilitate the provision of specific genetic materials if a purebred breeding program for swamp buffalo is adopted through the establishment of a nucleus-commercial breeding unit.

Optimising feed resources and genetic diversity

Malaysia has a huge acreage of land under plantation crops: 3.3 million hectares planted with oil palm and 1.7 million hectares planted with rubber. The rich supply of feed resources found in the plantation area offers adequate nutrients to support a sizeable population of beef cattle.

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Local beef production is currently adequate to meet less than 20% of the total beef demand of 92,553 tonnes. The existing beef and dairy cattle herds could not meet the demand for both breeding stock and feeder cattle. Malaysia has the capacity to significantly increase the beef supply through the optimal utilisation of local genetic and feed resources.

There are approximately 637,800 head of cattle in Malaysia of which approximately 3% are of the dairy-type and the rest are of the beef-type. The cattle population in the country has increased marginally by 0.8% annually over the past decade. In 1999, cattle supplied a significant proportion of the total beef production of 18,300 tonnes in this country. Besides cattle, buffalo have traditionally contributed towards the beef supply in this country. The population of buffalo has declined significantly at an annual rate of 2.8% in the past several decades following the cessation of their usage for ploughing and transportation purposes in rice-growing areas.

The supply of beef from cattle and buffalo has remained almost static with little expansion. It is envisaged that the demand for beef will continue to increase in anticipation of the recovery and continued prosperity of the domestic economy over the long term.

In beef production, the three major products in the up-stream phase are replacement heifers, breeding bulls and feeder cattle, whereas in the down-stream phase, the products are related with meat processing and packaging. The replacement heifers and bulls are utilised for breeding purposes to increase the number of calves produced both for the production of breeding stock replacements (heifers to replace cows and young bulls to replace breeding studs) and feeder animals for fattening and for the slaughter market.

In the Malaysian context, a consistent and dependable system in the supply of replacement heifers, breeding bulls and feeder cattle is not presently available. The commercial potential is huge in setting-up breeding herds to supply replacement heifers and bulls especially when integrated with oil palm crop. The supply of initial breeding stock from local sources for commercial herds could be supplemented with imports from Australia and Thailand.

Currently, there are a number of commercial beef cattle herds of medium size (of less than 300 cow-herd) found in many oil palm plantations owned or allocated to settlers. Besides supplying breeding stock, these commercial herds have the potential to supply feeder cattle for the feedlots and the slaughter markets. Supply of feeder calves from the current herds is inconsistent and the quality of the animals is variable in terms of age, size and breed types. As such, many beef feedlotters have resorted to imports of feeder calves from Australia and Thailand. The cattle imported from Australia meant for breeding and for the feedlots are mainly commercial crosses of Brahman-European stock. Body weight of these crosses ranges from 200 to 300 kg at 12 to 18 months of age. Phenotypically these cattle are heterogenous in terms of breed types, coat colour and body weight. The breeding stock and feeder cattle from Thailand are mainly Kedah-Kelantan based and Brahman crosses of less than 200 kg at 12 months of age. The animals are required to be quarrantined for veterinary examination at holding facilities on the Thailand-Malaysia border. With the lower ringgit exchange value vis-a-vis the Australian dollar, it is economically not viable to continue to import from Australia to meet our requirements for breeding stock and feeder cattle. Therefore, it is imperative and hugely viable to consider establishing more multiplier and commercial herds in oil palm plantations in this country.

The phase of producing calves from breeding cows has to be a least-cost operation, maintaining the cow population on low cost feed resources to achieve a high reproductive rate. The production system of integrating cattle with oil palm is well suited to undertake such an enterprise. Looking at the total animal requirement for maintenance and production or reproduction, including for milk production, and equating it with the total energy supply as provided by the vegetation found under the oil palms, it is evident that a productive enterprise is practical.

A rotational grazing system is recommended to ensure a long term or continuous supply of feed to the animals. A recommended stocking density of one cow to a hectare of oil palm is advocated. As the oil palm advances in age, the stocking density has to be adjusted to accommodate a reduction in dry matter on offer which determines the amount of energy available for maintenance and production of the cattle. Several strategies could be taken to adjust total animal requirement for energy and available feed resources within a given area, such as (1) reduce stocking rate, (2) maintain at recommended stocking rate and top-up shortfall in total energy from vegetation with feed supplements (compound feed of locally available feed ingredients, cut forages, conserved forages, preserved or processed agricultural by-products) and (3) shift the animals to a new area with a higher feed availability.

The low supply of feeder cattle from existing cattle herds in the country has been attributed to a number of limiting factors, both resource-based and policy-related. Current population of breeding cows, estimated at 250,000 head, is inadequate to meet the demand for breeding stock for the cow-calf producers and feeder cattle by existing feedlot operators. Based on an annual replacement rate of 15%, 37,500 head of yearling heifers are required to replace some of the female breeding stock culled for low fertility, disease and unproductive performance. For feeder cattle, to meet 40% of the production of slaughter cattle derived from growing-fattening operation carried out in feedlots, a total of 96,500 head of feeder cattle are required annually.

Although plentiful, the feed resources in rubber and oil palm plantations have not been exploited fully to support beef production. Yet beef production has to be a least cost operation in order to stay competitive. The huge supply base of feed resources in rubber and oil palm plantations is adequate to support a 500,000-cow population.

Priorities in beef development

Research and development strategies in livestock development should be one of supporting in the expansion of the industry. Genetic and breeding research in Malaysia could be geared to address the followings:

- introduction of improved genetic materials;
- mass breeding and distribution of selected genotypes;
- genetic improvement of multiplier-commercial units.

A breeding program based on an open nucleus breeding scheme is advocated to maintain a continous genetic progress. The program entails (1) population screening for potential foundation stock to be selected based on defined selection criteria, (2) setting-up of nucleus breeding units coupled with central performance testing and (3) dissemination of selected genetic materials to multiplier and commercial units.

As the deficiency in output supply exists in the ruminant sector, it is prudent to give a higher emphasis in funding for development in the cattle and buffalo sub-sector. Besides the production system of integrating ruminants with the plantation crops, other systems of management have to be explored to capitalise on the availability of feed resources found in situ.

Conclusion

The successful rearing of imported chicken and swine breeds under Malaysian conditions is facilitated by a readily available supply of quality feed ingredients sourced from local and global markets and an abundant supply of progenies for commercial production. For the ruminant sector to thrive as a viable industry, there must also be developmental efforts to produce progenies cheaply in large numbers and provide a consistent supply of quality feed materials. National breeding programs designed purposely for the improvement of domestic ruminant species are important in laying the foundation of a reliable herd improvement program while realising that their benefits and gains are long-term.

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Development Strategies for Genetic Evaluation of Cattle and Buffalo in Pakistan

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Abstract

There are 22 million cattle in Pakistan, belonging to eight distinct breeds. The majority of the cattle population belong to landless or small-scale farmers under an extensive production system. There are about 23 million buffalo. Nili-Ravi and Kundi are the only two breeds and both are river buffalo. There are no efforts at the public or private level to conserve livestock genetic resources. Efforts are especially needed for dairy cattle breeds such as Sahiwal, Red Sindhi and Cholistani and the draught breeds such as Lohani and Rojhan. Dairy cattle are under pressure of indiscriminate breeding to produce crossbreds while the utility of draught-type cattle is decreasing because of mechanisation. There are no foreign breeds of buffalo that they can be crossed with, although some crossbreeding occurs in the peri-urban intensive production buffalo colonies in Karachi and Hyderabad.

PAKISTAN is situated along both sides of the historic Indus River, following its course from the mountain valleys of the Himalayas down to the Arabian Sea. It shares borders with India, China, Afghanistan and Iran. Its 796,095 square kilometre territory includes a wide variety of landscapes, from arid deserts to lush green valleys to stark mountain peaks. The estimated human population is 138 million (Table 1) with an annual growth rate of 2.5%. Of the total population, 65% live in rural areas. Punjab is the most populated of the four provinces, having 56% of the country's population while Sind (23%), NWFP (16%) and Balochistan (5%) provinces share the rest.

Table 1. Human population.

Year	Population (millions)
1996	125.4
1997	128.4
1998 (census)	130.6
1999	134.5
2000	137.5

Of the total geographical area of 79.61 million hectares, 28% (22 million hectare) is agricultural land (arable and permanent crops, excluding meadows and pastures). About 70% of the cultivated area is canal irrigated. Fodder crops are grown on 12% of agricultural land (2.6 million hectare), of which 80% is irrigated and the remaining is rain-fed. The area under fodder crops has been decreasing over the years (Table 2). Forests are only 4.6% of the total geographical area (3.7 million hectare).

The agricultural sector contributes more than 25% to GDP and employs 44% of the total work force of the country. It is not only the main source of foreign exchange earnings, but also a linkage for promoting growth in the other sectors (GOP 2000). Within the agricultural sector, the livestock sector contributes 37% of agriculture value added and about 9% of the GDP. The per capita availability of livestock products is presented in Table 3. Per capita availability of milk is 163 litres while that of meat is 12 kg, most of which is from buffalo and cattle. It may, however, be mentioned that population statistics and statistics on the availability of products from various sources differ drastically.

Cattle Population

Basic statistics

There are 22 million cattle in Pakistan. They belong to eight distinct breeds (Table 4). The Sahiwal and

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Red Sindhi are dairy type while Tharparkar is considered dual purpose (dairy and draught type). The other five (Bhagnari, Dhanni, Dajal, Lohani and Rojhan) are draught type. The Cholistani (a dairy breed) and Dajal (a draught breed) have somehow been left out in the last livestock census (GOP 1996) probably because of their low numbers. The Sahiwal and Red Sindhi are well known dairy breeds for the tropics but their number has been decreasing over the years. Current estimates of these breeds are around 5% each. Some 58% of the cattle population is non-descript (Table 4). The crossbreds are mainly crosses of local cattle with some foreign breeds such as Holstein Friesian. Jerseys and other dairy breeds have also been used. These crossbreds are usually kept with buffalo to ensure the market demand of milk in the peri-urban production set up. The difference in calving pattern in buffalo and cattle match well to fill this niche.

The majority of the cattle population belong to landless or small-scale farmers under an extensive production system. Cattle herds have been estimated to be around 4.7 millions. Most of the cattle (56%) are in herds of less than 5. About 76% of the cattle are in herd sizes of 10 or less (Table 5). Traditionally, cattle have been raised to produce draught power. However, mechanisation has slowed their growth rate (Table 6). According to a recent livestock census

Table 2. Land use (million hectares).

Classification	1996	1997	1998	1999	2000
Total area	79.61	79.61	79.61	79.61	79.61
Cultivated area (arable and permanent crops)	21.68	21.98	21.96	21.93	21.99
Not available for cultivation	24.35	24.61	24.61	24.52	24.50
Permanent pasture	5.00	5.00	5.00	5.00	5.00
Forest area	3.61	3.58	3.66	3.60	3.66
Fodder area	2.72	2.65	2.68	2.65	2.56

GOP (2000a).

Table 3. Per capita availability of milk, meat and eggs (kg).

Product	1996	1997	1998	1999	2000
Milk*	121.06	123.89	147.31	157.96	162.81
Meat (total)	13.00	13.10	12.30	12.40	12.40
Buffalo and cow meat	6.40	6.40	6.40	6.40	6.40
Sheep and goat meat	3.70	3.70	3.60	3.60	3.60
Poultry meat	2.80	3.00	2.20	2.30	2.30
Eggs	2.20	2.20	2.15	2.20	2.20

*GOP (2000a); FAO (2001).

Table 4. Breeds of buffalo and cattle.

Species	Breed	Main utility	Population (thousand)
Buffalo	Nili-Ravi	Dairy	6778 (34%)
	Kundi	Dairy	4282 (21%)
	Others (nondescript)	Dairy	9213 (45%)
Cattle	Sahiwal	Dairy	1392 (6.8%)
	Red Sindhi	Dairy	1940 (9.5%)
	Tharparkar (Thari)	Dairy and draught	1413 (6.9%)
	Bhagnari	Draft (heavy type)	497 (2.4%)
	Dhanni	Draft (medium type)	1390 (6.8%)
	Lohani	Draft (light type)	232 (1.1%)
	Rojhan	Draft (light type)	213 (1.0%)
	Crossbreds	Dairy	1541 (7.5%)
	Others (nondescript)	Draft/dairy	11,806 (57.8%)

GOP (1996).

(GOP 1996), the number of bullocks have decreased from 5.1 million in 1986 to 3.4 million in 1996. Cattle still grow at the rate of about 2% annually and share 32% of the milk supply of country and 25% of the meat produced for the county (Tables 7 and 8). It has been estimated that some 75% of the draught power for cultivation is derived from bullocks. Furthermore, the animals will remain the principal energy source in Pakistan for decades to come (Akhtar and Shah 1987).

Table 5. Distribution of herd size.

Herd size	Cattle	Buffalo
1–2	16.3 %	18.1 %
3–4	22.0 %	24.5 %
5–6	17.2 %	17.4 %
7–10	20.0 %	19.6 %
11–15	9.9 %	10.2 %
16–20	4.8 %	4.2 %
21–30	4.3 %	2.9 %
31–50	2.9 %	1.6 %
>50	2.5 %	1.5 %
Total	20.4 millions	20.3 million

Source: GOP (1996)

Table 6. Population trend for ruminants and poultry (millions).

Species	1996	1997	1998	1999	2000
Buffalo	20.3	20.8	21.4	22.0	22.7
Cattle	20.4	20.8	21.2	21.6	22.0
Sheep	23.5	23.7	23.8	23.9	24.1
Goat	41.2	42.7	44.2	45.8	47.4
Camels	0.82	0.80	0.79	0.78	0.78
Poultry	184	200	145	148	148

Source: GOP (2000a); FAO (2001)

Table 7. Milk production (thousand tonnes).

Species	1996	1997	1998	1999	2000
Buffalo	18,705	19,868	19,868	20,489	21,138
Cattle	9,333	9,505	9,682	9,863	10,049
Sheep	30	30	30	30	31
Goat	509	527	546	565	586

Source: GOP (2000a).

Table 8. Meat production (thousand tonnes).

Species	1996	1997	1998	1999	2000
Buffalo	464	477	490	504	518
Cattle	434	442	450	459	467
Sheep	214	215	216	217	218
Goat	292	300	308	315	323
Poultry	355	387	284	310	322

Source: GOP (2000a).

Productivity information

Productivity data on various performance traits of cattle are available from the institutional herds. Sahiwal is the more extensively studied of the cattle breeds. Sporadic reports are available on the draught breeds, too. Average birth weight of dairy breeds is 20–30 kg, female calves are 2 kg lighter than the male calves. Weight at maturity varies a lot. Adult females weigh 300–350 kg while males are usually heavier than females by 100 kg or more. Weights for bulls of 1000 kg or more is not uncommon. Age at first calving is above 40 months. Males start producing viable sperm at the age of 2 years. Females produce 1200 litres of milk per lactation for a lactation length of 250 days. Milk fat percentage averages above 4.5%. Calving intervals and dry period are 450 and 150 days, respectively (Hasnain and Shah 1985). In draught breeds, milk yield may be half of the dairy breeds for a lactation length of 6–7 months. In the light draught breeds such as Lohani, females weigh around 250 kg. Weight gain of one kg/day has been reported under experimental conditions but generally it is around $\frac{1}{4}$ to $\frac{1}{2}$ of a kilogram. Dahlin (1998) reported that for 4700 Sahiwal cows, birth weight was 22 kg; weight at the age of one and two years, was 130 and 222 kg, respectively. Age at first calving, weight at post-partum and calving interval were 44 months, 319 kg and 465 days, respectively. First lactation mean values were 1365 kg, 1395 kg and 252 days for milk yield up to 305 days after calving, total lactation yield and lactation length, respectively.

The crossbred dairy cattle population has been increasing over the years. Crossbreds perform better than the local dairy breeds of cattle under similar managemental conditions. They mature earlier than the local cattle breeds by 8–10 months and produce 50% or more than the local breeds. Calving intervals of the crossbreds are shorter than the local breeds. However, susceptibility to diseases like Foot and Mouth Disease and external parasites is higher in crossbreds than in local breeds (Khan 1994). To maintain the exotic level between 50% and 75%, production of semen for AI has not been able to meet the demands. Reduced fertility has also been reported in crossbred bulls mainly because of severe summer conditions and genetic reasons.

Marketing of animals and their products is traditional. Live animals are marketed in the local markets called ‘mandies’ arranged by local governments. An entry fee is charged along with some percentage on the sale price. On special occasions like Eid, cattle from rural areas are brought to urban centres to fetch better prices. Type and appearance are the more commonly used attributes; actual live

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weight or other parameters are rarely considered. Slaughtering of animals is five days a week. Laws that prohibit slaughter of pregnant or sick animals are weakly enforced.

UHT milk has been available in the country for the past four decades but still more than 95% of milk used is raw milk for which a traditional marketing system prevails, especially in the urban areas. A class known as 'gawalas' controls the milk marketing. In the urban intensive system of milk production, milk moves through a series of middlemen. Fat content is the only criteria considered for the purchase of milk from producers under the commercial set up. Substandard milk, which is available even at below $\frac{1}{3}$ of the price of packed milk, is, however, sold openly. Apart from the huge price difference, homogenised milk gets less attention because at boiling, a thick cream layer does not appear indicating that perhaps it is devoid of fat (and other nutrients).

Constraints to production

Cattle have traditionally been kept to produce bullocks for draught power. Only $\frac{1}{4}$ of the 22 million cattle are classed as dairy animals with milk production potential (Table 4). For the two dairy breeds (Sahiwal and Red Sindhi), the production system is essentially low cost. The low genetic potential of indigenous breeds and health problems are the major constraints. Foot and Mouth Disease and occasionally the Rinderpest have also been serious constraints to the export of meat. Low producer prices for milk and meat discourage intensive cattle production, especially when the market is not open for these products and prices are regulated by the Government.

Raising cattle for meat, the price of which is about half as compared to mutton, is discouraging especially in the absence of grazing lands. Further, the fodder area is decreasing every year due to pressures of raising cash crops. Although cattle are well adapted to severe summer conditions prevailing in the areas of cattle production, it does affect productivity. April to August are the worst months as temperature may reach 50°C. Low rainfall in certain years resulting in drought condition may further aggravate the situation.

Genetic and breeding programs

Genetic and breeding programs to improve genetic potential of cattle for traits of economic importance are lacking. Animals are recorded at institutional herds only and data on various productive and reproductive traits are kept. Studies based on data from institutional herds have indicated that there has not been any genetic improvement in traits like milk yield (Dahlin 1998). A progeny testing program for Sahiwal cattle has been started in Punjab but it is limited to institutional herds.

Semen has been imported for the production of dairy crossbreds to cater to the needs of the peri-urban production system for use at farmer level in irrigated areas. Mostly it has been of the Holstein breed. Jersey semen has also been used in rain-fed areas. Other cattle breeds for which semen has been imported for limited and/or experimental use include Australian Illawara Shorthorn, Australian Friesian Sahiwal, Australian Droughtmaster, Swedish Red and White, Chinese Black and White, Charolais and German Simmental (Khan 1994). To locally produce semen of Holstein and Jersey, nucleus herds have also been established: one each in Punjab, Balochistan and NWFP provinces. National breeding policy prohibits the crossing of locally available purebreds, yet indiscriminate crossing continues and poses a major threat to the local breeds for which no conservation program is in practice. Limited studies on various quantitative aspects of breeding for major dairy breeds (Khan et al. 1997; Ahmad 1999) have been conducted. However, molecular genetic studies are limited. Karyotyping of the Sahiwal breed has been undertaken (Anis et al. 1990).

Buffalo Population

Basic statistics

There are about 23 million buffalo in the country. Nili-Ravi and Kundi are the only two breeds and both are river buffalo. Nili-Ravi is predominantly raised in Punjab while Kundi belongs to the Sind province. Nili-Ravi buffalo are 34% of the population while Kundi are 21% and rest are non-descript (Table 4). The buffalo number has increased by 2.5 million in the past five years and at present for every six persons in the country there is one buffalo. They are part of the traditional small mixed farming system integrated with crop production and are the backbone of the dairy industry in Pakistan.

Herd size is very small; 80% of buffalo are raised in herds of size 1–10 (Table 5). About five million small-scale farmers own them mainly for subsistence, as dairying is not quite commercial and the level of inputs is very low. Most of the milk available in the country (66%) comes from buffalo (Table 7) while their share in the meat produced in the country is 28% (Table 8). About 2% of draught power is also shared by them, apart from their contribution in dung and other products.

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Productivity information

Nili-Ravi is the most extensively studied of the two breeds in the country. Usually, they are black (sometimes brown) with white patches on forehead and legs, with tightly curled horns. They weigh about 35–40 kg at birth, 200–250 kg at one year and 300–400 kg at the age of 2 years. Age at first calving is about 4 years, gestation period slightly more than 10 months, lactation duration around 10 months, first lactation milk yield around 1800 litres and can produce for 10 lactations or more. Under a commercial set up, herd average of 2500 litres is common with 6.5% or higher butter fat test. Service period, calving interval and dry period average 200–250, 525–575, 225–275 days, respectively (Shah 1991). Adult buffalo weigh between 500 and 600 kg with males weighing 150 kg or more than females. Growth rate up to the first 2 years of age average $\frac{1}{2}$ kg per day but can be much better under optimum feeding and management conditions. Poor reproductive performance and late age at puberty are generally considered inherent problems of buffalo. But this may be more due to poor nutrition and adverse climatic conditions and lack of research for breeding buffalo artificially.

Kundi, from Sind province, weigh less than Nili-Ravi by 100–150 kg. They are usually black but dark browns are also found. Horns are tightly curled. Production performance may be comparable with Nili-Ravi especially under commercial set ups.

Crossbreeding with any exotic breed is not occurring because Nili-Ravi and Kundi are considered the best of the dairy buffalo breeds. Crossing Nili-Ravi with Kundi does not happen as such because of the more restricted hometracts (Nili-Ravi are mostly in Punjab and Kundi in Sind) except when Nili-Ravi buffalo are purchased from Punjab and taken to other provinces for intensive milk production in peri-urban production setups. There, local bulls are used to impregnate females. Generally, half the buffalo are non-descript because impregnating buffalo naturally is considered more important than finding bull semen that meets the breed characteristics. About 5% of the buffalo are being covered with AI as compared to 10–15% cattle where exotic semen is mostly used for the production of crossbreds.

The marketing system is similar to that of cattle. Inter-provincial purchase of buffalo for milk is much more common compared to cattle which are usually traded for meat instead of milk. Buffalo milk is preferred all over the country for its higher butterfat content and total solids. Buffalo meat on the other hand is eaten but has least priority compared to mutton, fish, poultry and cattle meat.

Constraints to production

Buffalo are popular livestock because of the quality milk they produce under substandard feeding and management conditions. Unavailability of adequate feed/fodder and limited heath cover are the major factors in reduced productivity of buffalo. Long summers may further hamper productivity. There is no genetic improvement program that can ensure availability of semen from genetically superior bulls. The one in vogue in central Punjab, if not expanded to widen the genetic base, and data recording and evaluations are not improved, is less likely to bring any change. Lack of an efficient marketing system and institutional weaknesses at planning and especially at implementation level and absence of a production oriented extension system can be added to the list. Everett (1979) noted that the livestock extension services in the country are mainly concerned with preventive and clinical veterinary medicine and lack the necessary training and incentive to be an effective force in developing the livestock production. It is still true today.

Genetic and breeding programs

A progeny testing program in Nili-Ravi buffalo is being carried out on a very limited scale in central Punjab. Recording of buffalo is mainly conducted in the seven institutional herds and a few military farms. Apart from these, buffalo at farmer level are recorded under the progeny testing program which has been carried out since 1980. About 8000 buffalo have been recorded with the farmers under this program and more than 80 bulls have been tested for their genetic worth for milk yield (Khan 1998; Khan et al. 1999). Recently born bulls had, on average, higher breeding values as compared to older bulls, indicating a positive genetic trend in the bull population for first lactation milk yield. Yet, their use was not judicious. Bulls with higher breeding values left fewer offspring compared to bulls with poor breeding values, probably because evaluations were available when most bulls had been culled. Animal identification also seemed to be a major challenge both at farm and field level. Frequent evaluation and sustained efforts are required before any impact can be seen from such a program.

Many studies are available on quantitative aspects of buffalo breeding and evaluation (Cady et al. 1983; Salah-ud-Din 1989; Khan et al. 1997a, Khan et al. 1997b) but molecular genetic aspects are yet not explored. Normal chromosomal pattern from lymphocytic cultures have been reported for Nili-Ravi breed (Ali 1986). Cryopreserved embryos have successfully been transferred in buffalo and techniques are being

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refined (Ullah and Anwar 1998) but field application is still far away.

Genetic conservation of cattle and buffalo

There are no efforts at public or private level to conserve livestock genetic resources in general. Efforts are especially needed for dairy cattle breeds such as Sahiwal, Red Sindhi and Cholistani and draught breeds such as Lohani and Rojhan. Dairy cattle are under much pressure of indiscriminate breeding to produce crossbreds while the utility of draught-type cattle is decreasing because of mechanisation. Buffalo are lucky that there is no foreign breed they can be crossed with. Still, some crossbreeding is going on in the peri-urban intensive production set ups such as those in buffalo colonies in Karachi and Hyderabad in Sind province where the best Nili-Ravi from Punjab are brought for producing milk and the local bulls are used to impregnate females. Most of the calves born are thus a cross of Nili-Ravi and Kundi breeds but they are of less importance because most (or maybe all) are slaughtered before one week of age. All buffalo producing less than three litres of milk per day are slaughtered irrespective of their genetic worth. Genetic erosion of extreme order is feared.

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Development Strategies for Genetic Evaluation of Beef Production in Pakistan

Nasrullah Panhwer[1] and U.N. Khan[2]

Abstract

Production of crossbred cattle is a short-cut method for increasing milk and meat production. Cattle crossbreeding in Pakistan was initiated in 1976 to achieve fast growth in milk and meat production. The results achieved so far under rural conditions indicate an improvement of 75% to 170% in milk production over the indigenous parents and reduction of 10 to 12 months in age of maturity and first calving. The total buffalo population according to the 1996 livestock census was 20.3 million. During the 10 years from 1986 to 1996, it has increased by 29%. With future trends of bioengineering and genetic selection, water buffalo have great potential as red meat producers.

PAKISTAN was born out of the partition of the South Asia sub-continent in 1947 when the British transferred power to the newly independent countries of India and Pakistan. Although the modern state of the Islamic Republic of Pakistan is half a century old, the land and the people have far more ancient origins.

Key Statistics

The official name is Islamic Republic of Pakistan, area 796,095 sq. km, population 130.58 million (Table 1); annual increase 3.1%, (1980–1991); crude birth rate 40.6 per thousand (1993); crude death rate 10.6 per thousand (1993); infant mortality rate 95 per thousand (1992); GDP growth rate 5.7% (1980–1994); per capita income US$470 (1992); literacy rate 37% (1994 Government estimate); climate sub-tropical, cold in highlands. Urdu is the official language although English is widely used in Government and business. Religion is Islam. Pakistan is bordered on the west by Iran, on the northwest by Afghanistan, on the northeast by China and on east by India.

Pakistan is divided in to four provinces Punjab, Sindh, NWFP (Northwest Frontier Province) and Balochistan. Pakistan is predominantly arid, with low rainfall and humidity and high solar radiation over much of the country. Most of its regions receive less than 200 mm annual rainfall, except the northern mountains which receive more than 500 mm annually. The rainfall distribution varies widely in the Sindh and Punjab provinces; 60% rainfall occurs during the monsoon season, commencing in late June to early September, while over Balochistan and northern mountains most rain falls between October to March (FAO 1995).

Land Utilisation

The land area of Pakistan, including Azad Kashmir, is 87.98 million hectares. The major land uses in the country are agriculture, forestry and livestock production. Of the cultivated area, 76% is irrigated through the canal system while the remaining 24% depends on rainfall. About 51.4% (45.2 million hectares) of the total land area of the country is classified as rangelands. Most of these rangelands receive less than 200 mm rainfall and there is little possibility of bringing them under irrigation. In addition to climatic factors, poor and rocky soils, deserts and rough topography also impose limitations. These factors make it impossible to use these rangelands for sustained (long-term) farming.

However, these rangelands support about 93.5 million head of farmed grazing animals during the summer and monsoon seasons, but heavy grazing over vast areas of rangelands has gradually put

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Table 1. Human Population of Pakistan (by province) 1951–1998 (thousands).

Province	1951	1961	1972	1981	1998
Punjab	20,557	25,500	37,612	47,292	72,585
Sindh	6,054	8,374	14,158	19,029	29,991
NWFP	4,587	5,752	8,392	11,061	17,555
Baluchistan	1,187	1,385	2,433	4,332	6,510
FATA	1,337	1,847	2,491	2,199	3,100
Islamabad		120	235	340	799
Total	33,816	42,978	65,321	84,253	130,058

intolerable pressure on land, vegetation and its inhabitants, such as wildlife, farmed livestock and pastoral communities. This is the result of a number of contributory factors, principally increases in human and animal population leading to the expansion of dry-land farming on marginal lands to satisfy the increasing demand for human food crops, and the cutting of shrubs and trees for domestic fuel consumption (FAO 1995). As a result of this, the more palatable grasses, legumes, herbs, shrubs and trees that once covered the rangelands have been destroyed or thinned out and replaced with unpalatable low quality vegetation. Therefore, each year inadequate forage during the dry period, combined with drought years, causes heavy losses of livestock.

Pakistan has about a dozen agro-ecological zones. Official statistics on the use of land (MINFAL 1997) are represented in Table 2.

Livestock

Pakistan is primarily an agricultural country and livestock plays a vital role in its economy by providing principal sources for essential items of human diet in the form of milk, meat and eggs. It also provides wool, hair, hide, skin, blood, bones, and farmyard manure and is a principal source of motive power for cultivation and rural transport. It is estimated that livestock plays an important role in the lives of about 35 million people or about 40% of the population. Livestock and their products provide a major source of food and regular cash income to this group of the population. With associated marketing and processing chains, it seems likely that the livestock sector provides employment for more than half the population of this country.

The livestock sector contributes about 8% to national income and about 28% to GDP from agriculture. It provides 85% of traction power for cultivation and transportation of agricultural produce from field to market. It also complements agricultural income by converting crop residues, agricultural by-products and wastes into milk, meat, wool, hair etc.

Feed Resources

It is estimated that about 2.7 million hectares of land is under fodder cultivation in Pakistan and produces about 51 million metric tons of green fodder annually. Thus, the average yield comes to about 19 tons per hectare which is very low. The total feed available from all resources is estimated at 37.35 million metric tons of Total Digestible Nutrients (TDN) and 2.37 million metric tons of Digestible Proteins (DP). There is deficiency of 12.54 million metric tons of TDN and 1.58 million metric tons of DP at present which is being coped with by the introduction of high-yielding varieties of fodder crops, use of fertilisers and better cultivation practices.

Table 2. Utilisation of land in different provinces of Pakistan (million ha).

Classification	Province				Total
	Balochistan	NEWF.	Punjab	Sindh	
Total	34.72	10.17	20.63	14.09	79.61
Forest	1.09	1.34	0.50	0.69	3.62
Not available for cultivation	11.16	4.03	2.93	6.27	24.39
Cultivable waste	4.66	1.05	1.76	1.44	8.91
Cultivated area (including fallow)	1.69	1.93	12.28	5.69	21.59
Area unreported	16.12	1.82	3.16	0.00	21.10

Fifty nine per cent of the total agricultural land is with 91% of the farmers who have less than 25 acres land. About 4.7 million families of which 75% have 12 acres or less than 12 acres of land own livestock in small herds and flocks. Apart from this, one million landless households contribute to livestock production as their sole means of livelihood. In the Punjab, one animal unit is being maintained on every 0.7 acres by small-holder farmers while the same animal unit is being kept on every 3.5 acres of land by farmers having more than 12.5 acres of land

Milk and Meat Contribution

Milk and meat products form integral parts of human diet and account for 70% of animal protein intake. The availability of milk is relatively high in Pakistan when compared to other regional countries.

Approximately 12.2 million tons of milk is produced annually of which 74% is contributed by buffalo, 21% by cows and the remaining 5% by sheep, goats and camels. The per capita availability of milk is 95 litres, which is less than the total production as 5% is fed to calves and 15% is wasted due to marketing constraints. Likewise, 1.22 million metric tons of meat is available from the livestock present in Pakistan, of which 44% is from cattle and buffalo and the remaining 56% is from sheep, goats, camels, poultry, etc. Approximately 0.57 million metric tons of beef, 0.53 million metric tons of mutton, 0.12 million metric tons of poultry meat is produced annually.

Livestock Wealth in Pakistan

Pakistan has been blessed with the finest breeds of animals, which possess tremendous potential and need to be exploited further. The over all genetic resources of the national herd are:

(1) buffalo, Nili Ravi in Punjab and Kundhi in Sindh are kept mainly for milk production.

(2) Sahiwal and Red Sindhi cattle are among the best tropical dairy breeds; other dairy breeds such as the Bhagnari, Dhani, Dajal, Rojhan Cholistani and Lohani are draught breeds, while the Tharparkar and Kankrej are kept as dual purpose breeds. These breeds posses extremely valuable traits of heat tolerance and disease resistance. These breeds have been exported to many countries in the world and are well known for their qualities. The same breeds have been developed for both milk and meat and reported to be in big demand due to their qualities. Livestock populations can be seen in Table 3.

The contribution of the livestock sub-sector in agricultural value added is 25–30% and about 8–10% in GDP (GOP, 1997, 1998, 1999, and 2000). The magnitude of various livestock produce is presented in Table 4.

Cattle Population

Basic statistics

There are about 10 different breeds of cattle found in Pakistan. Of these, Red Sindhi, Sahiwal and Cholistani are the dairy breeds, Tharparkar or Thari is a dual purpose (milk and draught) while the remainders (Kankrej, Bhagnari, Dajal, Rojhan, Lohani and Dhanni) are all draught-type animals. The dairy and draught breeds enlisted only represent <30% of the cattle population; the rest can only be classified as non-descript/rural cattle with a low milk yield (600–900 litres/lactation). Thus, these animals make a sizeable portion of the beef produced in Pakistan. Although, the coverage of the cattle population through artificial insemination is as low as 5–7%, the non-descript/rural cattle are the target animals for crossbreeding with exotic dairy breeds such as Holstein-Friesian and Jersey.

In the public sector, there are three farms of Red Sindhi; about a dozen farms maintain Sahiwal cattle and one farm each for Tharparkar/Thari and Bhagnari/Dajal cattle. Besides, there are a few farms maintaining immigrant cattle. These include a few

Table 3. Estimated livestock population 1997–2000 (millions).

Species	1997–98	1998–99	1999–2000 (E)
Cattle	21.2	21.6	22.0
Buffalo	21.4	22.0	22.7
Sheep	23.8	23.9	24.1
Goat	44.2	45.8	47.4
Camels	0.8	0.8	0.8
Horses	0.3	0.3	0.3
Donkeys	3.2	3.8	3.8

E: Estimated
Source: Ministry of Food, Agriculture and Livestock, Pakistan.

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Table 4. Livestock products.

Products	Units	1997–1998	1998–1999	1999–2000 (E)
Milk	('000 tons)	24,215	24,876	25,566
Beef	('000 tons)	940	963	986
Mutton	('000 tons)	617	633	649
Poultry meat	('000 tons)	284	310	322
Wool	('000 tons)	38.5	38.7	38.9
Hair	('000 tons)	16.7	17.3	17.9
Bones	('000 tons)	309.2	316.3	324.0
Fats	('000 tons)	115.2	117.8	120.6
Blood	('000 tons)	33.6	34.4	40.9
Eggs	Millions	5737	8261	8463
Hides	Millions	73	7.5	7.6
Skins	Millions	35.3	36.3	37.2

Source: Ministry of Food, Agriculture and Livestock, Pakistan

farms on Friesian cattle in Balochistan, one in Punjab for Holstein Friesian and Jerseys, one in the Federal Area maintaining Jerseys and one in North-West Frontier Province maintaining Friesian cattle. For Friesian × native crosses, there is only one herd in the public sector. With specific reference to beef, there exists a Beef Research Station at Sibi in Balochistan province, where Droughtmaster from Australia and native Bhagnari cattle are crossed. All farms in the public sector have a limited but recorded population.

Productivity

Among many constraints to livestock production, inadequate feed resources are classified as the major constraint in Pakistan.The livestock populations are supported by feed resources derived from crops, fodder, range lands, other grazing areas and agro-industrial by-products. It was estimated earlier (Akram 1987; Malik 1988) that the feed resources were deficient by 29.3% and 33.1% in TDN and DP, respectively.

Despite a reasonable genetic potential, the production potential of Zebu cattle is generally low. The young male calves are sold as surplus; older cattle as a result of culling and all other categories are sold when the owner is in need of money. The sales are arranged through open markets, butchers or on the basis of personal contacts.

Since a large population of cattle is scattered and raised on common grazing fields, they are more prone to parasitic infestation.

Genetics and breeding programs

The cattle owners do not generally practice record keeping. There are many reasons attributed to this, for example, small herd size for domestic use only, non-existence of a breeding program, low productivity of non-descript cattle which comprise >70% of the population and low literacy rate of the farmers.

Except a few progressive farms in the private sector, the Government and military farms invariably maintain recorded herds. These farms have information on health, pedigree and productive and reproductive performance of all animals.

The World Bank-funded National Coordinated Research Project on Cattle Crossbreeding terminated in June 1998. This project was helpful in initiating production of half-breed bovine semen. Presently, there is no national cattle-breeding program in existence, except a progeny-testing program on Sahiwal cattle in the Punjab province. Recently, genetic evaluation of Sahiwal cattle based on 20-year performance data generated at 11 farms has been completed in collaboration with FAO and Swedish University of Agricultural Sciences, Upssala. Sires produced out of select dams in the recorded population are used to serve respective breeds of native cattle. For non-descript cattle, either a locally available mating bull is used or they are crossed with Friesian/Jersey frozen semen.

A comprehensive program for the improvement of Sahiwal cattle in rural areas has been formulated. Primarily, the project will be initiated in Sahiwal, Okara, Khanewal, and Jhang districts and after success, the program will be extended to other districts.

Production of crossbred cattle is a short-cut method for increasing milk and meat production. The cattle crossbreeding in Pakistan was initiated in 1976 to achieve fast growth in milk and meat production. The results achieved so far under rural conditions are quite encouraging and indicate an improvement of 75% to 170% in milk production over the indigenous parents and reduction of 10 to 12 months in age of maturity and first calving. The department to

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upgrade non-descript cows in rural areas through crossbreeding has initiated a comprehensive program. For this purpose, 186 breeding cows of two world famous breeds, Friesian and Jersey, have been imported for the production of exotic bulls of high genetic merits.

The cattle population according to the 1996 livestock census is 20.4 million. It has increased by 19.2% during the period 1986 to 1996.

Buffalo Breeds of Pakistan

Riverine type buffalo of Pakistan belong to two breeds, i.e. Nili-Ravi of Punjab and Kundi of Sindh province. Nili-Ravi buffalo constitute approximately 79% of the total buffalo population in the country and are found in several parts of NWFP and AJK in addition to their primary home tract, which is in irrigated Punjab.

According to the last livestock census conducted in Pakistan during 1996, the buffalo population was 20.3 million. As per 1986 census, the population of buffalo has increased to 29.1%.

Pakistani buffalo are used as a triple purpose (milk, meat and draught) animal. They are the main dairy animals in the country, and more than 71% (13.4 million tons) of national milk production (18.94 million tons) is contributed by buffalo. Meat is an important by-product of buffalo. According to the recent estimates, more than 0.5 million tons of buffalo meat is produced per annum which constitutes about 50% of the total meat production in the country.

In addition to their use for milk and meat production, buffalo are an important source of draught power in the country. Buffalo are used for a variety of agricultural operations i.e. ploughing, especially in paddy fields, water lifting from wells, transportation of farm produce to nearby markets, etc.

The major problems faced by the buffalo breeders and farmers include poor reproductive efficiency, sub-optimum production potential, higher incidence of infertility diseases, lower rates, of calf survival and higher costs of feeding. Poor reproductive efficiency is mainly due to delayed onset of puberty (32–42 months) and longer calving intervals (18–24 months). Although the Nili-Ravi and Kundi of Pakistan are among the best dairy breeds in the world, their milk producing ability is still sub-optimal and there is considerable scope for their genetic improvement. Buffalo nutrition is another area where much research is required to develop economical feeding strategies for various stages of growth and the productive cycle of buffalo.

In order to address these problems of buffalo farming in Pakistan and to make the best possible use of available research and development resources, a National Coordinated Buffalo Research Program (NCBRP) was initiated by the Pakistan Agricultural Research Council in 1992 for a period of six years. The NCBRP is a part of the overall Agricultural Research Project (ARP-II) sponsored by the World Bank under a loan to the Government of Pakistan.

The main objective of NCBRP was to improve reproductive efficiency and production performance of dairy buffalo of Pakistan through research on reproduction, breeding, nutrition and disease control. Buffalo research and development activities of seven research institutes located in various parts of the country are under this program.

In the field of male buffalo reproduction, research activities were aimed at improving semen evaluation and processing techniques, development of suitable extenders for buffalo semen and studies on comparative physiology of buffalo and cattle spermatozoa in terms of sperm capacitating and acrosomal integrity.

In the field of female buffalo reproduction, the research work is focussed on reducing the calving

Table 5. Comparison of cattle population as reported in 1986 and 1996.

Cattle	1986	1996	% Difference
Total	17,132,536	20,424,458	19.2
Bullock (3 years and above)	5,300,482	3,669,885	–30.8
For breeding	201,949	280,828	39.1
For work	5,098,533	3,389,060	–33.5
Cows (3 years and above)	6,586,253	10,020,935	52.1
In milk	3,948,416	6,326,144	60.2
Dry	2,102,684	2,381,095	13.2
Not yet calved	535,136	1,313,698	145.5
Youngstock (below 3 years)	5,245,822	6,733,642	28.4
Male	2,792,915	3,568,181	27.8
Female	2,452,907	3,165,461	29.0

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interval. Suckling by calf, inefficient heat detection and higher ambient temperatures during summer months have been identified as the common non-genetic factors responsible for longer calving intervals of buffalo.

The important issue of economical rearing and fattening of male buffalo calves for increasing meat production in the country is studied under the NCBRP; efforts are underway to develop economical and efficient early weaning diets for calves. Experimental work completed so far indicates that diets based on cottonseed meal can be successfully and economically used for early weaning.

The Asian buffalo meat production, which accounts for 19–92% of the world total output in recent years, recorded 4.15% of an annual increase during the past decade. India was the largest buffalo meat producer (1182 thousand tons) in 1992, followed by Pakistan (465), China (253), Nepal (96) and Thailand (63). In both India and Nepal, more meat is produced from buffalo than from cattle in spite of the fact that the buffalo population is outnumbered by cattle 1 to 3 in India and 1 to 1.5 in Nepal, due to Hindi religious beliefs and sentiments towards cattle. Water buffalo are exported for slaughter from India and Pakistan to the Middle East and from Thailand and Australia to Hong Kong. Demand for meat is so great that Thailand's buffalo population has dropped from 7 million to 5.7 million head in the past 20 years, a period in which the human population has more than doubled.

Water buffalo is one of the world's important domestic animals. During the past two decades, it has been convincingly demonstrated that this animal can be a supreme source of quality meat.

Those countries housing the world population of approximatly 160 million water buffalo should be aware that this ruminant not only has the unique ability to assimilate and utilise low quality forages but also has demonstrated excellent feed conversion rates with feed grains such as corn, sorghum and barley.

Today, water buffalo when reared with proper nutrition (quality/quantity), husbandry management and health care programs, can produce satisfactory yields of lean, tender red meat. The historic value of buffalo as work animals or as dual-purpose work/milk producing animals has taken precedence over their potential as meat producers. Until two decades ago, buffalo were slaughtered either as young veal calves or most probably, as mature spent draught animals. Recent research work on nutrition conversion capacity and carcass evaluation has established that the eminent future of the water buffalo as a domestic animal is as a meat producer.

Buffalo meat is becoming popular in developing countries and is gradually gaining recognition in the advanced meat importing countries of the west. The buffalo shows performances comparable to cattle in feed lot operations. Because of the lower nutritional demands, lean red meat from the buffalo is produced at lower costs than beef from cattle. In Bulgaria, Egypt, Italy, the Philippines and Yugoslavia, buffalo on full feed programs demonstrated daily weight gains exceeding one kg per day.

Additionally, numerous by-products are derived from the buffalo and there is little carcass waste. Hides are used in the manufacture of high quality leather goods. Cartilage and tendon are used for Kropeck. Horns are decoratively carved. The remainder of inedible portions is processed as tallow, glue, steamed blood and bone meal. In summary, water buffalo carcass is lean with a low percentage of fat deposition. In comparison with cattle, the buffalo carcass has rounded ribs a higher proportion of muscle and less fat. The flavor is comparable to that of beef in steaks as well as in processed meat products.

Buffalo Population

Basic statistics

As indicated above, small-scale farming is predominant in Pakistan. However, the buffalo herds vary from 10 to 200+ animals and contribute significantly to peri-urban dairying. In big cities such as Karachi and Lahore, there are cluster populations of buffalo comprising as many as 0.8–1.0 million animals purely kept on a commercial basis. Due to the consumers' choice for buffalo milk, this animal is excelling cattle at a faster rate as shown in Table 6.

Table 6. Growth in livestock population from 1986 to 1996 (millions).

Species	1986	1996	% increase during 10-year period
Cattle	17.13	20.42	19.2
Buffalo	15.70	20.27	29.1

Interestingly, Pakistan's buffalo population, which has now exceeded 20 million head, is yielding more than 70% of the total milk produced in the country.

Productivity

Some statistics on buffalo productivity are summarised in Table 7. It may be indicated that these are only the national averages, the potential of individual animals could be much higher.

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Most of the farming and management practices resemble those described earlier for cattle. The major difference is that buffalo are mainly stall-fed and better cared for in severe weather as compared to cattle. The surplus male buffalo calves contribute significantly to the country's breef production.

Genetics and breeding programs

Although buffalo plays a viable role in commercial milk production, most managers do not generally practice proper record keeping. They may be interested in keeping a track of the total milk production of the herd but records on breeding are largely missing. This makes it practically impossible to run a successful breeding program in the field. In the early 1980s, the Livestock and Dairy Development Department in the Punjab province initiated a progeny testing program on Nili-Ravi buffalo with the financial assistance from Pakistan Agricultural Research Council. Later, the Asian Development Bank assisted in infrastructure development to execute this program on a larger scale. Although presently no donor funding is available, the project is still in progress through core funding and it has completed testing of about half a dozen batches of future sires.

The GTZ was successful in organising buffalo farmers in the central Punjab province on a cooperative basis. Their efforts have led to establishment of a self-sustained farmer organisation named *Idar-i-*Kissan, jointly patronised by GTZ and the Government of Punjab. These efforts have also generated interest among farmers in breeding for better animals.

Along with a few progressive farms in the private sector, the Government and military farms invariably maintain recorded herds. These farms have information on health, pedigree and productive and reproductive performance of all animals.

The World Bank funded National Coordinated Research Project on Buffalo Breeding was terminated in June 1998. This project was helpful in strengthening the on-going progeny testing program on Nili-Ravi buffalo and the establishment of a modern semen research laboratory.

Researchers at the University of Florida in March 1986 completed comparative feed trials and carcass evaluation between top quality crossbred beef cattle bulls and randomly-selected water buffalo bulls. Charts from these investigations testify to the ability of water buffalo to perform favorably in the production of quality meat. With future trends of bioengineering and genetic selection, water buffalo have great potential as red meat producers.

The total buffalo population according to a 1996 livestock census was 20.3 million. During the 10 years from 1986 to 1996, it has increased by 29%.

Genetic Improvement

Nili-Ravi buffalo is ranked as the finest breed in the world. According to the FAO yearbook, Pakistan has 9% of the total buffalo population of the world and provides 28% to 30% of the total milk produced in the world. This is an indication of high milk producing capability of Pakistani buffalo. Although the average milk production of Nili-Ravi buffalo all over the country is 1800 litres in 305 days of lactation, 30% commercial buffalo produce 2500 to 4000 litres and above. A project for identification of buffalo bull mothers and production of progeny tested bulls involving Government Livestock Farms and livestock owners has been initiated primarily in four districts of Punjab for improvement of the production potential of rural buffalo. This project will be extended shortly to other districts.

Genetic improvement of indigenous water buffalo populations could be greatly accelerated by the use of artificial insemination and embryo transfer. Import and export of frozen semen from superior males permit international distribution of genetic

Table 7. Comparison of buffalo population as reported in 1986 and 1996.

Buffalo	1986	1996	% Difference
Total	15,704,454	20,272,873	29.1
Male buffalo (3 years and above)	197,402	360,855	82.8
For breeding	79,870	197,851	147.7
For work	117,533	163,011	38.7
Female buffalo (3 years and above)	8,979,127	12,211,116	36.0
In milk	5,724,406	7,809,518	36.4
Dry	2,337,492	2,433,301	4.1
Not yet calved	917,231	1,968,295	114.6
Young stock (below 3 years)	6,527,933	7,700,894	18.0
Male	2,371,100	3,286,239	38.6
Female	4,156,833	4,414,655	6.2

Table 8. Productive performance of buffalo and cattle breeds of Pakistan.

Breed	Type	Av. milk yields (305 days) lit.	Calving interval (days)	Lactation period (days)	Dry period (days)	Weight (kg)	
						M	F
Nili-Ravi	Milch	2300	504	318	186	800	590
Kundi	Milch	2000	500	320	180	600	375
Red Sindhi	Milch	1800	442	251	191	552	318
Sahiwal	Milch	2200	471	291	180	660	376
Bhagnari	Draught	800	495	236	259	545	341
Dhanni	Draught	800	578	270	308	409	318
Lohani	Draught	700	539	239	300	272	250
Rojhan	Draught	900	507	288	219	386	295
Tharparkar	Dual purpose	1200	552	237	315	504	285
Cholistani	Milch	1800	470	290	180	660	376
Kankrej	Dual purpose	1200	545	230	320	591	432

material. Such controlled breeding programs yield the best results on well managed farms which give high priority not only to nutrition but also to parasites and infectious disease control, and which maintain excellent records. Embryo transfer has been done and embryos have been frozen and thawed successfully in water buffalo. International trade in frozen embryos would further accelerate global distribution of elite water buffalo germplasm. While feasible today, these advanced procedures remain a technique of the future. They provide an exciting and challenging goal of providing the world with superior water buffalo, which in turn will provide mankind with milk, meat, power and companionship.

The current buffalo/cattle meat production system in Pakistan and particularly in Sindh is traditional and inefficient. Most of the meat comes from old or emergency slaughtered animals. With few exceptions, very little fattening activity is being carried out in Pakistan. Also about 0.2 million buffalo calves are slaughtered at 1–2 weeks of age in Karachi alone. Some calves are raised on commercial dairy farms but on unbalanced diets and they show some very poor daily weight gain.

The first very serious problem which heavily penalises the development of a sound beef feeding industry is the almost absence of good weaning techniques to develop a viable beef industry in the commercial sector. Too many young animals are left to die from diseases or starvation in their first week of life and those who survive generally are severely under fed.

A proper weaning technique is essential to prepare healthy and thrifty calves for the fattening industry. However, proper weaning of young calves at commercial dairy farms need encouragement and training to rear calves, which ultimately will be used in the fattening industry.

In late 1993, a concise market survey of Pakistan's livestock was conducted by the US Feed Grain Council (USFGC). The major constraints affecting beef production in Pakistan, as well as its potential were analysed and reported. Also, recommendations were made as to how some of the constraints could be eased, or lifted. I realise that the problems of the beef sector are well known to public officials, meat merchants and producers.

The report stated: *Current buffalo/cattle meat production systems in Pakistan are traditional and inefficient. Most of the meat comes from end of career, or emergency slaughtered animals. With a few exceptions, practically no commercial fattening activity is being carried out in Punjab, Sindh regions. A lot of baby buffalo, or beef calves are sent to slaughter at 1–2 weeks of age. Some calves are raised to 60–80 kg on extremely poor and unbalanced diets and only a few are raised to heavier weights with very low average daily gains.*

The lack of commercial, or farm livestock feeding in Pakistan could, to a large extent, be blamed on the existing ceiling price of beef meat which is fixed too low to let the production develop. Merchants and butchers also use the fixed price as a fictitious constraint to pay a low price to producers. However, on many occasions, it was possible to observe how the fixed price could easily be circumvented by the retail trade, when the demand for quality meat would command a higher price.

A second major constraint was found in the meat slaughtering/wholesale/retail marketing structure and techniques which are very traditional and highly unsanitary. The way the industry is practiced today in Pakistan is not acceptable in a country which is striving hard to improve the living standards of its citizens. The situation becomes even more unrealistic when those involved in the meat sector are planing *to develop meat exports under the present conditions. Should quality beef ever be produced in this country, its sale to most foreign markets would be impossible. Very few countries, in fact, would ever buy meat, which was not properly processed, handled and chilled.*

Because of the above production/marketing situation, beef is considered by Pakistani consumers as a second class, low quality meat, only fit to low income people who can not afford to buy lamb, goat, or poultry meat. Conversely, the beef production potential in Pakistan is very large. Estimates of the buffalo/beef male calf numbers available for feeding each year go from 2.5 to about 5 million head.

Genetic Conservation of Cattle and Buffalo

Pakistan has large diversity in cattle and buffalo germplasm. There are about ten breeds of cattle and two breeds of buffalo jointly comprising over 40 million head. There are several farms in the public sector primarily established as the demonstration farms. Today, these farms have lost their utility in terms of demonstration of livestock management practices to the farmers. They lack qualified manpower to cater for the genetic improvement of these animals. At the same time, these farms plus the military dairy farms are the only source of recorded population of cattle and buffalo and they can play a leading role in providing a recorded base population for the genetic improvement of the breed.

As a partner in the FAO initiative on conservation and utilisation of Animal Genetic Resources, Pakistan developed a national action plan during mid-1990s; however, due to lack of funding these activities are in suspension. Efforts are still underway to develop a national strategy for the conservation and utilisation of our native breeds.

As regards in-vitro conservation, there are about a dozen Semen Production Units available in the country to preserve germplasm of buffalo and native cattle, as well as that of exotic cattle breeds, namely Friesian and Jerseys.

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Genetic Evaluation of Beef Production in the Philippines

Dinah Loculan[1]

Abstract

Cattle farms in the country are predominantly of the backyard type. Herds being established are mostly purebred Brahmans, some commercial animals and native cattle (Busuanga Breeding and Experimental Station and Ubay Stock Farm). The government has established four nucleus farms and two participating private nucleus farms. A multi-breed cattle registry (Philippine Cattle Breed Registry, PCBR) will maintain the computerised database on standard performance and inventory of all registered cattle nationwide. Currently, two nucleus farms, namely Busuanga Breeding and Experimental Station (BBES) and Ubay Stock Farm (USF) maintain native cattle herds. BBES is maintaining a 60-cow native cattle herd.

AGRICULTURE is a major contributor to the Philippine economy because of its wide range of natural resources scattered all over the archipelago. The Philippines' total land area is 300,000 sq. km, 30% of which is devoted to agriculture. As of the year 2000, the human population was estimated at 76.5 million. Close to 60% of the Filipinos reside in the countryside. This sector contributes a 20% share to export earnings. Moreover, the country has a large agricultural base that grows at an average of 3.2% annually.

Within the agricultural sector, the livestock and poultry sub-sectors are the major contributors to Philippine agriculture (Table 1). In 1999, 29% of the total value of agricultural output was contributed by these sub-sectors. This contribution had always been consistently high.

Table 1. Share of livestock and poultry in agriculture output (million pesos).

	1995	1997	1999	% share*
Rice and corn	103,694	115,825	119,686	21.82
All other crops	126,702	161,001	179,310	32.69
Livestock/poultry	115,443	145,873	159,725	29.12
Fisheries	83,084	80,711	89,803	16.37
Total	428,923	503,410	548,524	100.00

* 1999; *Source:* Bureau of Agricultural Statistics, 2000a.

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Cattle, carabao and goats have had minor contributions. These different levels of contribution have impacted on the supply situation. While the country had attained self-sufficiency levels in pork and poultry, there remains a growing dependence on imports of beef and an almost absolute dependence on milk.

A thrust, therefore, identified by the Department of Agriculture had been to focus on these commodity groups.

Table 2. Share of the different livestock and poultry commodity groups (million pesos).

	1995	1997	1999	% share*
Hog	52,964	66,273	74,977	46.94
Chicken meat/eggs	44,038	56,816	60,500	37.88
Cattle	8,427	11,485	10,888	6.82
Duck meat/eggs	4,225	4,712	5,164	3.23
Carabao	3,196	3,620	4,676	2.93
Goat	2,495	2,849	3,390	2.12
Dairy	97	118	130	0.08
Total	115,442	145,873	159,725	100.00

* 1999; *Source:* Bureau of Agricultural Statistics, 2000a.

The livestock and poultry sub-sectors consist of several commodity groups (Table 2). The groups have different shares in overall production. Of the total output, hogs account for the biggest share: 47% in 1999; poultry including meat and eggs, account for more than 40%. These two commodity groups therefore account for more than 87% of total output.

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This marked performance of the sub-sectors was due to the sustained growth in production in response to the growing demand for meat and meat products in the domestic market.

Table 3. Per capita utilisation: meat (kg/year).

Meat	1995	1996	1997	1998	1999
Pork	14.00	14.72	15.13	15.36	15.91
Chicken	5.83	6.51	6.96	6.75	7.03
Beef	2.31	2.53	2.77	2.66	2.77
Carabeef	2.84	2.97	3.27	3.01	3.31
Chevon	0.98	0.98	0.98	1.01	1.01
Duck	0.14	0.15	0.15	0.15	0.15
Total meat	26.10	27.86	29.26	28.94	30.18

Source: Eleazar 1999.

Pork remains by far the most popular meat (Table 3). Consumption has increased in the past five years, probably due to the increase in income and in the price of other protein sources, particularly fish. Chicken is second to pork in terms of consumption. The average per capita intake had reached 7.03 in 1999 (Eleazar 1999).

Consumption of beef and 'carabeef', although significantly lower than that of pork and poultry, has shown proportionately higher increases over the past five years (Eleazar 1999).

The major reasons for the low level of development of the cattle sub-sector are the limited population and low productivity of stock. Poor genetics and poor technology practices, in the main, explain the low productivity. This is particularly true in carabao, goats and sheep. Hence, the government primarily addresses the matter of genetic improvement of these ruminant species.

Cattle Population

Basic statistics

Cattle farms in the country are predominantly of the backyard type. According to 1997 cattle industry figures, animal holding in backyard farms constituted 91% of the population as against the commercial sector's share of only 9%.

On the national level, cattle inventories show increasing trends over the past six years (1995–2000) (Tables 4 and 5).

Since 1993, an Administrative Order No. 3 was issued by the Secretary of Agriculture allowing the private sector to import feeder and breeder cattle to rebuild the cattle population of the entire country; as well as the importation of feeder cattle for fattening to fill up the short supply of feeder cattle as a temporary expedient.

The cattle industry appears to be the least developed, based on the country's almost absolute reliance on imports of milk and substantial imports of beef

Table 4. Number of ruminant species, 1992 to 1999 ('000 head).

Species	1992	1993	1994	1995	1996	1997	1998	1999	2000
Carabao	2570	2570	2550	2700	2840	2968	3024	3006	3024
Cattle	1730	1910	1930	2020	2130	2270	2380	2420	2479
Goat	2300	2560	2630	2820	2840	3025	3083	3051	3151

Source: Anon. 2000b.

Table 5. Cattle population and slaughter rate.

Particulars	1995	1996	1997	1998	1999	2000
Population (1000 hd)	2020	2130	2270	2380	2420	2479
% Population growth	—	5.45	6.57	4.85	1.68	2.43
Slaughter (1000 hd)	629	686	753	779	810	812.1
% Slaughter growth	—	9.06	9.77	3.45	3.98	0.26

Table 6. Cattle Importation by the private sector.

Particulars	1995	1996	1997	1998	1999	2000
Breeder stock	11,193	3,896	1,269	704	827	2,056
Feeder stock	188,343	176,156	253,464	186,131	253,032	196,777
Total	199,536	180,052	254,733	186,835	253,859	198,833

Source: Anon. 2000b.

(Table 6), and the alarming decline of the herd population. The overall direction for cattle is, therefore, to build up the population base, increase animal productivity, and lay the groundwork for sustained development.

One strategy for building up the cattle population base is through genetic infusion of superior quality cattle. Since the start of the 19th century, the Philippines has been importing cattle of different breeds.

Among the cattle breeds that have been popularly raised as indigenous in the country are descendants of those cattle brought into the country by the Chinese and Spaniards. The most prominent type of Philippine cattle is the Batangas type, believed to have originated from the yellow cattle of Southern China, which in turn evolved from the wild cattle (Indian Zebu) in Java and Brahmin archipelago. Other identifiable Philippine cattle types are: the Large Ilocos and Small Ilocos found in Northwest Luzon and Iloilo cattle found in Panay Island. Through the importation of different exotic cattle breeds, there developed a non-descript cattle with unknown blood composition. Of the imported cattle breeds, Brahman is the most popular and accepted by farmers because of its adaptability. Table 7 shows the list of imported cattle breeds brought into the country since the start of the century.

Productivity information

Production performance data are currently being recorded and collated in government-run nucleus farms. Herds being collected are mostly purebred Brahmans, some commercial animals and native cattle (Busuanga Breeding and Experimental Station and Ubay Stock Farm). So far, average daily gain from purebred cattle ranges from 0.46 to 0.62 kg/day and 0.25 to 0.35 kg/day for native cattle. Figures vary for the commercial cattle, from 0.75 to 1.25 kg/day, depending on the type of feed given and management system employed.

Genetics and breeding programs

General strategy

In 1997, the National Genetic Resources Improvement Program for Livestock and Poultry (NGRIP) was launched as a component of the Medium Term Livestock Development Program (MTLDP) (Anon. 1997). Purebred cattle imported from the United States of America are brought into the nucleus herds/ flocks on identified government stations and participating private farms. BREEDPLAN recording is used to assist in selecting the best stocks. Superior stocks are then increased in numbers in multiplier herds. These are often private farms that are collaborating with the government. Finally, improved genetics flows down to the village level either through the use of improved sires by artificial insemination (AI) or by the use of live bulls for natural service. Improved sires will be used for upgrading local stock for crossbreeding.

Table 7. Breeder cattle importation.

Year introduced in the Philippines	Quantity (head)	Type and Name of Breed
1900–1935	15	Dairy cattle (4), Jersey, Shorthorn, Holstein, Guernsey Beef cattle (5), Galloway, Angus, Devon, Hereford, Sussex (Zebu) Beef cattle (3), Nellore, Hariana, Bhagnari (Zebu) Dual purpose (3), Sahiwal, Red Sindhi, Tharparkar
1946–1970	12	Dairy cattle (1), Brown Swiss Beef cattle (8), Brahman, Chiricano, Santa Gertrudis, Ongole, Charolais, Charbray Braford, Red Poll Others (3), Red Danes, Australian Illawara, Balinese, Madura
1871–1983	9	Beef cattle (9), Indu-Brazil, Droughtmaster, Beefmaster, Belmont Red, Beefalo, Chianina, Marchiagiana, Simmental, Maine Anjou
1990	2	Dairy (1), Australian Friesian Sahiwal Dual-purpose (1), Simbrah
1993	8816	Simbrah
1994	6893	Brahman, Simbrah, Holstein Sahiwal
1995	12,546	Senepol, Nellore, Simmental, Brahman
1996	3648	Brahman, Senepol

Source: Anon. 2000b.

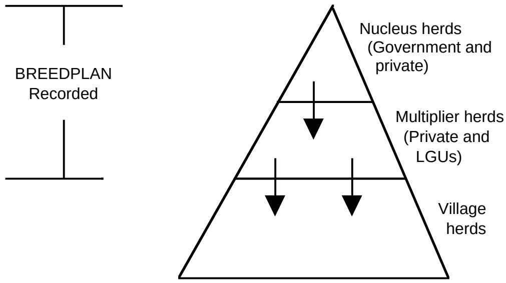

Figure 1. Schematic of the process used by BREEDPLAN.

The government has established four nucleus farms and two participating private nucleus farms. These contain herds of purebred Brahman and Simbrah. At present, all of these government herds are recorded on BREEDPLAN. For beef cattle, the participating farms are: Busuanga Breeding and Experimental Station, Milagros Stock Farm, Ubay Stock Farm, Malaybalay Stock Farm, ANSA Genetics Inc. and Sarangani Agricultural Corporation Inc. Around 98 members of the Federation of Cattle Raisers' Association of the Philippines (FCRAP) are also part of the network because they are recipients of purebred cattle dispersed by the government. FCRAP herds are also to be recorded on BREEDPLAN.

The improved genetics from this program are distributed to local government breeding centres and stations from which the genetics flows to the village level to improve productivity.

Records and genetic evaluation systems

It is only through accurate and reliable records that a sound breeding program can be properly assessed and given direction. All farm data gathered, analysed and compiled shall be used in planning, monitoring and evaluating the breeding program. All efforts are exerted to monitor production and performance of imported animals (Brahman and other breeds). Through the ACIAR Project entitled 'Performance Evaluation and Genetic Improvement of Ruminant Animals in the Philippines', a Central Data Management Unit (CDMU) has been established within the Department of Agriculture. Specific objectives of the project includes:

a) storing existing breeding and performance records taken from ruminant species (including indigenous breeds where available) in a national database;
b) undertaking research to estimate the genetic parameters and fixed effects relevant to the various ruminant species in the Philippines;
c) customising existing BREEDPLAN genetic evaluation software so that a standard parameter-driven system for all ruminant species in the Philippines;
d) training Filipino scientists to ensure self-reliability in running the national genetic evaluation program.

A multi-breed cattle registry (Philippine Cattle Breed Registry, PCBR) will maintain the computerised database on standard performance and inventory of all registered cattle nationwide. Active participation by the Federation of Cattle Raisers' Association of the Philippines and other Cattle Raisers' Cooperatives are seen. The PCBR shall conduct annual genetic evaluation of animal performance records leading to the publication of a National Breeder's Catalogue which shall highlight the estimated breeding values (EBVs) of outstanding breeder bulls and cows per breed in the country(Anon. 1999).

We expect to have a total of 3000 individual animal records added to the database coming from the beef nucleus farms.

Data recorded at the farm level are the following: sire, dam, birth date, birth weight, 200-day weight, 400-day weight, and 600-day weight, mature cow weight, scrotal size, days to calving, gestation length, calving ease. As of June 2001, the volume of data added to the database are as follows: 1800 records (Busuanga Breeding and Experimental Station), 260 records (Milagros Stock Farm), 100 records (Malaybalay Stock Farm), 250 records (Ubay Stock Farm) were encoded into Herd Magic, a customised PC herd recording software package.

Breeding objective

The general objectives of the Nucleus Farm Network are to systematically improve, propagate and conserve breeder beef cattle in the Philippines and to develop an appropriate distribution and transfer scheme that will provide a connection between the improvement gained in the breeding work and their ultimate utilization in the local production system. The specific objectives include the evaluation of the performance of selected breeds of beef cattle under Philippine conditions; establishment of breed performance standards for beef cattle including the establishment of local selection indices in the Philippines; implementation of a local scientific selection program for cattle; establishment of a breeder base population (gene pool) which will be the source of genetically superior performing cattle in terms of production, reproduction, adaptation and resistance to diseases; and the production of genetically superior purebred cattle for distribution and transfer to other nucleus farms, multiplier farms or interested ranchers/breeders, livestock cooperatives and smallhold breeders (Anon. 1997).

The objectives of the Multiplier Farm Network are to produce crossbred beef cattle through natural breeding or AI–using semen from purebred bulls; to evaluate the performance of crossbred beef cattle under Philippine conditions and to identify and promote the best crosses of beef cattle for commercial production (Anon. 1997).

The general objectives of the Male Breeder Loan Program are to make purebred and crossbred bulls available to smallhold breeders/ranchers, cooperatives, backyard-based breeders and other interested persons or groups who are not capable of direct purchase of purebred and crossbred male breeders from progressive private farms.

Breeds and mating systems

The nucleus (elite) purebreeding farms which practice an intensive selection program shall primarily maintain and improve the Brahman breed. This is because purebred Brahman is predominantly raised in the nucleus farms. Brahman is known for its adaptability to tropical conditions, hardiness, excellent foraging ability, heat tolerance and resistance to ticks. Two nucleus farms are assigned as gene pools for Simbrah and follow breeding guidelines prescribed in DA Administrative Order No. 14.

At the multiplier farms level, a crossbreeding program will be followed. This shall determine the best breed to cross with Brahman cows and produce the crossbred calves to be used as feeder stocks. Semen from Simmental, Angus, Simbrah, Charbray, Tuli, Beefmaster, Senepol and Wagyu will be used. A number of bulls (Senepol, Simbrah, Charbray, Tuli and Brahman) will be maintained at the National Artificial Breeding Center for semen collection.

The use of multiple ovulation and embryo transfer (MOET) will also be used in selected nucleus farms.

Mating systems for the nucleus and multiplier farm network mostly follow the controlled breeding scheme for 3 months.

Distribution and transfer schemes

Nucleus Farm Network—BAI and DA-RFU stations with at least a 200-head cow herd and a developed pasture area of at least 50 hectares are used.

Multiplier Farm Network—LGU stations and centres, progressive private farms, cooperatives, academic and R&D institutions with at least 25 hectare of developed pasture area and with the capability to take care of animals.

Male Breeder Loan Program—Smallholder breeders/ranchers, cooperatives, backyard-based breeders and other interested persons or groups.

Institutionalisation of the Unified Artificial Insemination Program

The Unified National Artificial Insemination Program (UNAIP) integrates current AI initiatives and have defined a 5-year strategy to complement the Genetic Improvement Program. This also serves as a tool for genetic linkage considering that Luzon and the Visayas islands are not yet FMD free areas.

On a national level, success rates of AI in cattle and carabaos are yet limited and noted to be below the established standards. In carabaos for instance, the AI field results in terms of conception rates and calf drops vary significantly as shown by previous works and studies.

AI is a potent tool in effecting genetic improvement and enhancing production efforts. Concerted efforts from all the AI stakeholders in improving the current delivery system will be implemented.

The UNAIP further hoped to improve AI performance from the current state to the desired level providing optimal productivity that is beneficial to the farmers.

(i) Goal

The goal of the program is to provide better opportunities for farming communities to improve their household income and become competitive by raising productive animals using practical technologies such as AI.

(ii) Long term objective

To localise and institutionalise AI delivery systems at the village level by 2015.

(iii) Medium term objectives

i. to accelerate AI diffusion rate to 30% of breedable female water buffalo and cattle by 2004;
ii. to improve conception rate at field level of water buffalo and cattle nationwide by 65%; and
iii. to improve the genetic quality of the water buffalo and cattle population and contribute to this increase from the 1999 level by 3% and 8% respectively in 2005.

(iv) Short term objectives

- to strengthen the AI management structure from the national to field level by unifying all AI activities and by creating a strong central coordinating and monitoring team;
- to strengthen the capacity and capability of the DA personnel through a more focused Human Resource Development Program;

Table 8. Patterns in the carabao sub-sector.

The supply situation	1994	1995	1996	1997	1998
Slaughter (1000 hd)	289	277	265	283	301
Meat equivalent of slaughter (m.t.)	52,263	50,094	47,925	51,256	113,050
Total supply from local (m.t.)	9,165	16,681	23,838	30,147	65,274
Total supply from import (m.t.)	61,427	66,775	71,763	81,403	21,382

Source: Anon. 2000b.

- to increase the municipal and barangay AI coverage from 26% in 1999 to about 50% by appointing and training local government units permanent AI technicians;
- to conduct a massive information campaign on AI by producing farmer-friendly information, extension/education and communication materials;
- to institutionalise a uniform incentive package, recognition and award mechanisms to deserving AI technicians; and
- to establish strategic semen and liquid nitrogen production and distribution centres and network.

Buffalo Population

Basic statistics

The majority of the carabao population is raised in backyard farms. In 1997, animal holdings on backyard farms constituted about 99.8%; the share of the commercial sector was a mere 0.2%.

Industry programs for carabao have traditionally been oriented toward its development as a draught animal. With increasing reliance on mechanisation and a greater demand for beef and milk, the industry needs to be developed also as a source of meat and milk.

The total carabao population was pegged at 3 million in 1999. The importation of live carabaos for genetic improvement and the implementation of a slaughter ban in 1995, coupled with the importation of buffalo meat from India, contributed to the sustained growth of the carabao population (Table 8).

The government, through the Philippine Carabao Center embarked on importation of buffalo for meat as well as for milk.

Seventy percent of the imported carabao are Bulgarian Murrah buffalo. These animals have been used for milk production in Bulgaria and are being milked in some centres of the Philippine Carabao Center. They produce up to eight litres of high fat (7.25%) of milk per day over a 300-day lactation period. This compares with 1.5 litres per day of milk production from native carabao. For the centres that are recording milk production, data are entered into a modern computerised database and analysed regularly by BREEDPLAN software appropriately customised for milk production traits, so that superior buffalo can easily be selected. A similar program will be put in place with the native swamp buffalo where selection will be based on growth traits and draught. Superior genetic material can be rapidly disseminated to village farmers because the Philippine Carabao Center has AI and ET facilities and excellent contact with village cooperatives.

Genetic improvement program

The national water buffalo genetic improvement program (GIP) was developed to address the issue of preserving the existing genetic resource for long-term breeding goals and at the same time harnessing available germplasm from all possible sources for improving the production potential of carabaos. The focus of the program is to improve the animal's genetic potential for milk and meat.

To achieve the program objectives, it becomes imperative to establish a sustainable mechanism for the selection and production of the carabaos and riverine buffalo. This would essentially lead to the establishment of a gene pool that allows for the selection and propagation of the best available swamp and riverine buffalo. Under the current set-up, the swamp buffalo are represented by the Philippine Carabao (PC) and the riverine buffalo are represented by the American Murrah buffalo (AMB) and the Bulgarian Murrah buffalo (BMB) (Table 9).

A master breeding plan was installed for each buffalo breed, defining that each breed group shall focus on a major production trait such as PC for draft, BMB for milk, and AMB for meat.

The gene pool for each breed group shall be kept as an open nucleus herd (ONH). Selected progenies shall undergo performance and progeny testing and only progeny-tested animals shall be used for sires under each breed group's GIP.

Table 9. Inventory of animals maintained at the PCC Network (by breed, class), 2000.

Breed[a]	Cow	Bull	Heifer	Cull	Total
Philippine Carabao	48	27	37	10	122
Bulgarian Murrah	632	304	575	373	1884
American Murrah	111	77	78	70	336
Indian Murrah[b]	6	18	29	5	58
Total	797	426	719	458	2400

[a] Purebred animals at the farmer-cooperators not included.
[b] Being maintained at PCC at CLSU.

Gene Pool Establishment

Gene pool for Philippine carabao (for draught)

To date, about 122 superior PCs are in the gene pool for the indigenous carabaos. These animals are maintained in a few PC centres identified for this purpose.

By the middle of 2000, the assignment of PC centres to undertake long-term selection and propagation of elite PC had been fixed as a result of a comprehensive review to rationalise the functions of the various centres in the PCC network.

Having recognised the possibility of some genetic distance between animals in some major islands within the country, the concept of having three PC gene pools, one each for the major islands has been defined and the PC centre for the purposes are:

a) PCC at CSU, Piat, Cagayan (PC gene pool for Luzon);
b) PCC at LCSF, La Carlota, Negros Oriental (PC gene pool for Visayas);
c) PCC at MLPC, Kalawit, Zamboanga del Norte (PC gene pool for Mindanao).

Gene pool for American Murrah buffalo (for meat)

A separate gene pool for the American Murrah buffalo (AMB) has been identified as early as 1996 and the facility in Ubay Stock Farm, Ubay, Bohol has been fully improved in 2000. This move has been reached to address the need to provide the desired genetic material for improving the carabao for meat production.

Undoubtedly, AMB has been developed through long-term selection and breeding for improving meat production efficiency.

Gene pool for Bulgarian Murrah buffalo (for milk)

Bulgarian Murrah buffalo (BMB) has been identified to be the major source of germplasm for genetic improvement for milk. Essentially, this breed group is a product of four generations of continuous crossing and backcrossing of Indian Murrah breed and the indigenous Bulgarian buffalo with milk production as the basis for selection over the years. These animals are practically close to purebred Indian Murrah. The only advantage is that this germplasm resulted from long-term, organised selection and breeding in Bulgaria.

Under the program, substantial numbers of this germplasm has been infused either in the form of live animals or frozen semen.

A national gene pool for BMB has been established at the PCC national headquarters and gene pool at Muñoz, Nueva Ecija. This comprises the elite animals out of the stock infusions. Other herds are at the PCC at CMU, PCC at USM and PCC at VISCA.

There are considerable numbers of animals given out to farmer-cooperators, the aim of which is to monitor the breed performance and to provide enough basis to select and test the most suitable animals under actual farmers' environmental conditions.

Germplasm pool for Purebred Indian Murrah buffalo (for milk)

Progenies of the Indian Murrah buffalo (IMB) imported into the Philippines in the 1950s are available in limited number and are currently maintained at PCC at CLSU. This facility was originally the Dairy Section of the Central Luzon Agricultural College, now Central Luzon State University, when the 1950s stock importation of Indian Murrah buffalo germplasm was received.

Over the years, only few progenies have been selected based on production and purity of Indian Murrah blood. For purposes of harnessing this highly inbred, selected stocks, a separate herd is now being maintained.

Germplasm Acquisition and Current Stocks

Infusion and current stocks of live animals

From 1994 to 1999, a total of 3420 head buffalo have been imported mainly from the U.S. and Bulgaria. However, for year 2000, no live animals from any source have been infused owing to fund limitation. The records of importation from 1994 to 1999 are shown in Table 10.

Table 10. Importation of riverine buffalo germplasm, Philippines, 1994–1999.

Year	Quantity	Source
1994	237	United States of America
1995	459	Bulgaria
1996	403	Bulgaria
1998	1656	Bulgaria
1999	665	Bulgaria
Total	3420	

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Towards the end of 2000, the number of purebred buffalo maintained at the institutional facilities is shown in Table 9. On the other hand, the number of BMB at the farmer-cooperators, forming part of the germplasm pool of BMB in the country, as of the end of 2000, is summarised in Table 11.

Table 11. Number of Bulgarian Murrah Buffalo (BMB) in the Farmer Cooperatives (by class), 2000.

Main island	Cow	Bull	Heifer	Cull	Total
Luzon	192	7	936	56	1192
Visayas	106	6	3	38	152
Mindanao	243	14	150	75	482
Total	541	27	1089	169	1826

Infusion and utilisation of frozen semen

The importation of AMB in 1994 was accompanied by frozen semen from selected sires available in the U.S.

On the other hand, the latest infusion of germplasm of riverine buffalo in the form of frozen semen was in 1998 from Bulgaria. The semen were derived from the best progeny-tested sires and were only released by the National Buffalo Research Institute in Shumen, Bulgaria as a result of drastic reduction in government support resulting from the economic slump experienced by Bulgaria for the years preceding 1998.

Selection and Propagation of Superior Stock

System for selection and testing

One of the significant outputs of the GIP efforts in 2000 is the completion of the individual animal recording system. This single effort makes possible the establishment of the very foundation for selection and genetic improvement.

Also, during the year, the initiation of the installation of a records analysis system, DAIRY STORE, under the Australian Centre for International Agricultural Research (ACIAR) Project, for use in the entire buffalo GIP was realised. During the year, technical staff members of PCC directly involved in the record analysis were sent to Australia for training. The Australian personnel continue to liaise with their counterparts in the Philippines.

Around 295 individual daily milk records from 295 elite cows at PCC Gene Pool are already input into the Dairy Store system.

Selection and testing of superior animals

The GIP team completed the selection of candidate animals as replacement heifers in the National Gene Pool. These animals underwent selection on the basis of their pedigree performance records.

Some 50 head of male progenies of BMB were also selected and were subjected to growth performance test. This resulted in the identification of 15 head bulls for semen collection and thus for progeny testing. This brought the number of potential sires undergoing progeny testing to 37 head.

Production of purebred stocks

During 2000, the number of calves born at the PCC network and at the farmer-cooperatives is summarised in Table 12.

Table 12. Calves born at the PCC Network and Farmer-Cooperatives (by breed group), 2000.

Breed group	PCC network	Farmer-cooperatives
Philippine Carabao	10	—
American Murrah	70	—
Bulgarian Murrah	373	169
Indian Murrah	5	—
Total	458	169

Use of reproductive biotechnology

The use of reproductive biotechnology to enhance the multiplication of superior germplasm is an important component of the overall genetic improvement program.

In 2000, the efforts were focused on the area of in vitro production and cryopreservation of buffalo embryos.

Towards the end of last year, the techniques for in vitro fertilisation and culture of buffalo embryo were refined to the extent of achieving a success rate of up to 30% from the previous rate of only 18%.

With the promising output of in vitro embryo production and the achieved efficiency of cryopreservation techniques, efforts on the establishment of a satellite Embryo Biotechnology Laboratory in India have been initiated.

Recruitment and training of support staff to work on the large-scale in vitro production of purebred riverine buffalo embryo has already been conducted. Coordination and arrangements on the procurement of equipment for the laboratory followed. By January 30, 2001, the initial production of embryos had started. Efforts on training technicians that will implement the embryo transfer activities were also initiated.

With the concerted effort of the Philippine government and the private sector, the project is expected to go into full production at the start of 2001. A significant impact will be realised by 2003 and a considerable effect on the dairy industry will take place at approximately 4–5 years onwards.

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Genetic Conservation of Cattle and Buffalo

Cattle

Currently, two (2) nucleus farms, namely Busuanga Breeding and Experimental Station (BBES) and Ubay Stock Farm (USF) maintain native cattle herds. BBES is maintaining a 60-cow native cattle herd. Experimentation with regards to purebreeding, crossbreeding and performance data recording and collation are the main activities undertaken. USF on the otherhand, is maintaining a 30-cow herd of Bali cattle since 1998.

Buffalo/Philippine carabao (for draught)

To date, about 122 superior PCs are in the gene pool for the indigenous carabaos. These animals are maintained in a few PC centres identified for draught.

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Cattle and Buffalo Production and Breeding in Sri Lanka

Anura S. Premasundera[1]

Abstract

Sri Lanka's human population growth has slowed down when compared to that of 50 years ago. Due to a drastic reduction of the death rate, the population is increasing even though the birth rate has decreased. The livestock sector production levels have not increased significantly, even though during the past 100 years breed improvement coupled with the introduction of management and feeding techniques have not made an impression except in the poultry sector which at the moment is in the hands of the private sector. This situation may have been due to the fact that no consideration has been given to the farmers' resource base and the farming system adopted by the farmer. The production levels and performance by most of the improved cattle and buffalo breeds are far below their genetic potential. Unless new policies and techniques are used to evaluate genetic improvement and involve the present high yielding animals in different agro-ecological zones and in different production systems in the country's breeding scheme, introduction of new genetic material will not contribute to an increase in production in the future. Today, the dairy sector is dependent on imports up to 80% and the meat sector to around 30%. In years to come, this situation is bound to deteriorate so that the country will have to depend more on imports.

SRI LANKA is located between 5° 54′ and 9° 52′ north latitude and 79° 39′ and 81° 55′ east longitude, at the southern point of the Indian subcontinent. The land area of Sri Lanka is 65,610 square kilometres (6,570,134 ha) administratively divided into 8 provinces and 25 districts, which are further divided into Assistant Government Agents Divisions (AGA divisions).

Topographically, the island consists of a south central mountainous region which rises to an elevation of 2500 metres, surrounded by broad lowland plains at an elevation 0–75 metres above mean sea level. From the mountain region, nine major rivers and 94 other rivers drain across the lowlands into the Indian Ocean.

Though the overall climate is tropical, it shows variations across the country mainly due to differences in rainfall and elevation. The rainfall shows seasonal fluctuations and is dependent on the southwest and northeast monsoons and on conventional effects.

The mean temperature ranges from 30°C in the dry zone to 27°C in the wet zone, in the mountain region due to the high altitude the mean monthly temperature varies from 17.8°C to 26.8°C.

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Economic Situation and Human population

When the then Ceylon became independent in early 1948, the then population of around 7 million were depending on agriculture as their main source of income and the agriculture sector contribution to GDP accounted for more than 40%, which decreased to 19.7% by the year 2000 (Table 1). Even though the agriculture sectors' contribution to GDP and to employment was considerable, Sri Lanka imported most of its food due to the fact that the agriculture sector mainly consisted of plantation crops.

At the time of independence, the government's main policy was to become self sufficient in food. Immediately after independence, the state sector invested heavily in the opening of new land for food cultivation and irrigation. People were settled in these newly opened agriculture production areas beside restoration of ancient irrigation systems. The result of this policy is that Sri Lanka at present producers around 85% of its rice requirement. At present (year 2000), even though the contribution of agriculture to the GDP is 19.7%, the contribution of the livestock sector to GDP is around 0.9 %. However, livestock makes a major contribution to the economy by utilising the labor and land which, as

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Table 1. Composition of GDP as a percentage of GDP.

Year	Agriculture	Mining and quarrying	Manufacturing	Construction	Services
1960	38.5	0.5	11.5	4.4	45.1
1970	28.5	0.7	4.4	5.6	48.7
1980	24.3	3.5	5.6	5.4	53.0
1982	26.4	2.4	5.4	8.4	48.5
1990	23.2	3.0	8.4	6.8	49.6
1995	20.0	2.4	6.8	5.2	50.2
1997	19.8	2.5	5.2	5.0	51.4
1999	20.7	1.4	5.0	4.0	52.3
2000	19.4	1.9	4.0	6.0	54.6

Table 2. GNP per capita and Real GNP per capita.

Year	1950	1960	1970	1980	1990	1995	1997	1999
GNP per capita Rs.	532	675	1019	4559	18,797	36,387	47,409	57,257
Real GNP per capita Rs.	500	652	737	1433	1864	2213	2269	2350

well as crop residues and other roughages as fodder, has resources for which there would be very little alternative use.

During the period from 1950–1999, the GNP per capita increased nearly to 10 fold, even though in real value, it increased only four fold (Table 2). The present GNP per capita of Sri Lanka is classified under the low-income group ($766–$3035) (Table 2).

Human Population

The human population of Sri Lanka was 19.359 million in the year 2000 (Central Bank of Sri Lanka report year 2000). At the beginning of the 20th century, the population in Sri Lanka was only 3.56 million, and at independence, the population was 7.3 million, recording an increase of only 3.74 million. During the past 51 years after independence, the population of the country has grown by 12.059 million. The rate of increase of the population which was 22% during the first decade after independence (in 1948), increased to 31% in the second decade and stood below 20% thereafter. During the second decade, the rate of increase of the population was 13.77%. From 1990 to 2000 the annual rate of increase of the population decreased from 1.5 in 1991 to 0.9% in 1992, thereafter increasing to 1.7% in 2000 (Table 3). The population projections for Sri Lanka for the year 2031 is 24.85 million at high estimation and 19.9 million at low estimation (Census and Statistics, Population and Labor force Projections for Sri Lanka 1991–2031).

Table 3. Population projections for Sri Lanka, 1991–2031 (in millions).

Year	Standard	High	Low
1991	17.25	17.259	17.259
1996	18.11	18.157	18.051
2001	19.015	19.068	18.711
2011	20.873	21.271	19.671
2021	22.323	23.226	20.060
2031	23.128	24.859	19.092

The death rate has shown a rapid decrease during the past 50 years. In 1945, the death rate was 21.5 per 1000 persons and in 1999 it decreased to 5.9. The birth rate also shows a gradual decrease during the past 50 years. In 1945, the birth rate was 35.9 per 1000 persons and in 1999 it decreased to 17 per 1000 persons.

Though the birth rate has shown a considerable decrease during the past five decades, during the same period, the death rate has shown a rapid decrease. As a result, the population is showing a slow increasing trend.

This trend is leading to a gradual ageing of the population in that the percentage of the population up to 45 years was 80% and the percentage of the population above 45 years was 19.9%. However, the standard population prediction for the year 2031 gives the percentage of the population below 45 years as 57.1% and that of the population above 45 years as 42.7%.

Land Use

The land use pattern in Sri Lanka has undergone major changes since the 19th century when extensive forests found in the hilly regions as well as large tracts in the plains were cleared. It now comprises of a plantation sector growing mainly tea and rubber as well as a large domestic food production sector with rice being the main food crop.

Food production is overwhelmingly a smallholder activity. Most of the rice—the staple—is produced in the dry zone with irrigation and large areas of primarily farmland have been brought under irrigation in recent decades. Shifting cultivation continues to be practiced in part of the uplands but is now a relatively minor form of land use.

The land use changes were most sharply expressed in the contraction of the tea and rubber areas and more generally in the area under permanent crops. Between 1956 and 1994, the area under tea fell by 11.56% while that under rubber fell by 7.81%. The total land area under permanent crops fell both absolutely and relatively, excluding the increased area devoted to paddy, which is extensively grown in the low country. The dense forest area declined by 8.0%, open forest by 3.5% and grassland by 0.5% (Table 4).

Per Capita Availability of Livestock Products

The per capita availability of all meat varieties except that of poultry meat shows a declining trend. The per capita availability of poultry meat has shown a nearly twofold increase. The availability of eggs has shown a slight increase of 10% in the past decade. The increase in the per capita availability of milk is due to a large increase in the import of whole milk powder and other dairy products, the country's formal market milk collection and processing has not increased during the past decade (Tables 5, 6 and 7).

Table 4. Land use (hectares).

LAND USE	1956, ha	1956, %	1982, ha	1982, %	1993, ha	1993, %
Buildup and non ag. land	12,243	0.186606	15,212	0.231859	29,190	0.44491
Homesteads	340,984	5.19723	367,061	5.594692	731,280	11.14607
Tea	228,000	3.475144	171,130	2.608340	201,630	3.073216
Rubber	216,238	3.295869	193,001	2.941694	199,030	3.033587
Coconut	116,353	1.773436	179,214	2.731554	170,000	2.591110
Mixed and other crops	21,591	0.329087	48,978	0.746516	82,030	1.25029
Paddy	155,360	2.367975	163,194	2.48738	800,470	12.20065
Other crop land	262,607	4.002619	219,534	3.346106	88,190	1.344179
Grassland	130,500	1.989062	110,000	1.676604	92,190	1.405147
Dense forest and f. plantation	1,862,910	28.39421	1,794,290	27.34831	1,335,160	20.35032
Open forest	650,000	9.907208	588,000	8.962212	424,680	6.472912
Mangrove	19,410	0.295844	19,410	0.295844	19,410	0.295844
Marsh, swamp and water	332,920	5.074319	332,920	5.074319	332,920	5.074319
Barren land	110, 000	1.676604	90,200	1.374816	77,480	1.180939
Spare land	2,006,764	30.58681	2,175,983	33.16602	1,918,390	29.23982
Other land	95,000	1.447976	92,753	1.413728	58,790	0.896069
TOTAL	6,560,880	100	6,560,880	100	6,560,880	100

Table 5. Per capita availability of livestock products (kilograms/annum).

Meat varieties, eggs and milk	Kilograms per year						
	1994	1995	1996	1997	1998	1999	2000
Beef	0.95	1.52	1.34	1.37	1.33	1.31	1.4
Pork	0.11	0.13	0.12	0.12	0.11	0.12	0.12
Mutton	0.17	0.16	0.13	0.15	0.13	0.11	0.11
Poultry	2.02	2.17	2.16	2.54	3.19	2.95	3.43
Eggs	48 eggs	53 eggs	52 eggs	52 eggs	54 eggs	55 eggs	53 eggs
Milk and dairy[a] products (litres)	24.24	26.85	25.67	27.87	31.4	30.6	32.5

[a] = Includes milk collected in the formal market + dairy products and milk imported.

Table 6. Per capita consumption of meat by sectors 1986/87 and 1996/97 (grams per person per month).

Sector	Beef		Chicken		Mutton		Pork	
	1986/87	1996/97	1986/87	1996/97	1986/87	1996/97	1986/87	1996/97
Urban	245	196	78	239	20	23	12	8
Rural	65	68	19	87	3	3	14	14
Estate	81	86	26	140	16	9	5	0
All sectors	99	85	30	109	7	6	13	13

Source: Report on Consumer Finances and Socio Economic Survey, Sri Lanka 1996/97.

Table 7. Per capita consumption of eggs by sector per month.

Sector	Egg (number/month)	
	1986/87	1996/97
Urban	4	3
Rural	2	2
Estate	2	3
All sectors	2	3

Source: Report on Consumer Finances and Socio Economic Survey, Sri Lanka 1996/97.

During the past decade, the daily calorie intake in different sectors has shown a marginal increase of 5% to 7% (Table 8).

Table 8. Per capita daily calories intake for different sectors.

Food item	Calorie intake			
	Urban	Rural	Estate	All sector
Rice	746	1063	1066	1022
Wheat flour	65	65	641	97
Bread	349	224	106	233
Coconut	222	290	229	278
Sugar	192	179	143	179
Meat, fish, milk	177	116	81	122
Vegetables	39	42	32	41
Condiments	57	53	50	54
Other	348	303	325	307
All items total	2195	2336	2674	2337

Source: Report on Consumer Finances and Socio Economic Survey, Sri Lanka, 1996/97.

If the per capita availability of livestock products are to be maintained at 1998 level, then the increase of demand due to the population increase at high estimation levels in the year 2031 requires the production to be increased by 25%. Table 9 gives the required levels of production of meat and the required production of milk at 1998 consumption levels and at 40% self sufficiency level.

Meat Markets

The meat market for beef consists of village level collectors, area collectors and main suppliers who supply the slaughter houses in the urban areas; some of these suppliers are owners of meat retail shops and local slaughter houses. Due to an increase in demand and constraints in the supply of animals for meat during the past five years beef prices have increased by around four times. Slaughter of buffalo is illegal even though illegal slaughter of both cattle and buffalo amounts to around 30% of the meat supplied to urban areas.

The animals are transported live to the slaughter houses by lorry and all of the slaughter houses except that of the capital Colombo are either makeshift structures or are simply closed sheds. The meat is sold except in super markets without grading or as cuts. The transport of cattle either for breeding or for slaughter needs a permit from the veterinary surgeon of the area. The market margins in the marketing channels for meat marketing varies from Rs.0.20/kg and Rs.20/kg, the higher margins are realised at the wholesale stage of meat marketing.

Table 9. Production level of livestock products needed to maintain the per capita production levels of 1998.

Item	1998/capi	1998 in mt	2011 (mt)	2021 (mt)	2031 (mt)
Beef	1.33	24,924.2	28,289.1	30,882.6	33,050.5
Pork	0.11	2,061.4	2,339.7	2,554.2	2,733.5
Mutton	0.13	2,436.2	2,765.1	3,018.6	3,230.5
Poultry	3.19	59,780.6	67,851.3	74,071.8	79,271.5
Milk*	4.6	86,204	97,842	106,812	114,310
Milk at 40% self sufficiency	10.2 L	192.47 mill. litres	212.87 mill. litres	227.66 mill. litres	235.82 mill. litres

* Milk production in million litres.

Population growth trends for cattle and buffalo from 1993 to 2000 are given in Table 10, and the cattle farming systems used in the various agro-climatic areas of Sri Lanka are given in Table 11. Table 12 details the distribution of various cattle breeds in the different climatic zones and Table 13 shows productivity and performance data for local and crossbreeds of cattle and buffalo. Tables 14, 15 and 16 details buffalo population trends in various climatic zones, average herd sizes and the percentage of herds carrying improved breeds in the differenct zones.

Table 10. Population growth trend for cattle and buffalo, 1993–2000.

Year	Cattle millions	Trend %	Buffalo millions	Trend %
1993	1,704,100		793,800	
1994	1,702,500	–0.09389	791,100	–0.340136
1995	1,704,100	0.093979	763,900	–3.438251
1996	1,644,000	–3.52679	760,900	–0.392722
1997	1,578,800	–3.96594	725,800	–4.612958
1998	1,599,000	1.279453	720,700	–0.702673
1999	1,616,700	1.106942	727,700	0.9712779
2000	1,610,500	–0.3835	727,000	–0.096193

Table 11. Cattle farming systems and their main features.

Agro-climatic zones	Main production	Characteristics of the farming system	
		Herd size breeds	System features
Hill country zone	Milk	1–3 animals per unit High percentage of exotic blood Holstein, Friesian, Jersey, Ayrshire and their crosses	Stall feeding only, zero grazing, high level of concentrate feeding, major diseases are metabolic diseases, and tick fever. High level of milk production
Mid country	Milk	2–4 animals per unit cross breds of European breeds	Both zero grazing and tethering small number grazed, concentrates given in all feeding systems in moderate amounts, main diseases are tick fever and metabolic diseases, contagious rare. High to moderate milk production
Coconut triangle (parts of western Province and North West Province)	Meat, milk	2–10 animals per unit European and Indian zebu crosses Indian zebu and local crosses	Free grazing or tethering under coconut where stall feeding with grazing is practiced concentrates are given in low amounts. Low incidence of BQ and sporadic cases of HS. Controlled vaccination
Low country wet zone	Meat, milk	2–10 animals per unit majority indian breeds and their crosses, local breeds	Night housing with tethered grazing practiced concentrates are given in low amounts. Low incidence of BQ and sporadic cases of HS. Controlled vaccination
Low country dry zone	Meat	Large herds ranging from 5 to more than 150 animals	Majority night paddocking or kept in open enclosures, free grazing and no concentrates given, HS and FMD endemic regular vaccination carried out

Table 12. Cattle breed distribution.

Agro-climatic zone	Percentage pure breed	Percentage cross bred	Percentage local breed (non-descript)
Wet zone	5–10% (majority European)	35–70% (majority European crosses)	20–60%
Wet intermedate zone	5–10% (majority Indian breeds)	35–60% (majority Indian crosses)	30–55%
Dry intermediate zone	5–8% Indian breeds	30–40% (Indian cross breds)	52–65%
Dry zone	2–3% Indian breeds	20–30% Indian breeds	67–78%
For the whole country	2% pure European 8% Indian	12% European 17% Indian	61%

Table 13. Productivity and performance information.

Parameters	Cattle			Buffalo	
	European crossbreds	Indian crossbred	Local non-descript	Cross breds	Local breeds
Reproductive performance					
Age at 1st heat (months)	14–20	16–22	24–28	24–30	24–30
Age at 1st parturition (months)	26–32	28–34	36–40	38–42	38–42
Inter parturition interval (months)	13–16	13–15	12–14	16–18	16–18
Number of calving	5–7	5–7	6–9	5–7	5–7
Milk yield					
Milk yield/day (litres)	6–15	4–6	1–3	5–6	2
Length of lactation (days)	300	270	180	280	155
Lactation yield (1000 litres)	1.8–4.5	1.08–1.6	0.18–0.54	1.8–2.1	0.36
Milk fat %	3.2–4.0	3.5–4.5	3.5–4.5	6–8	7–9
Growth					
Birth weight (kg)	25–35	20–25	15–18	25–3	20–25
Weight at 1st year (kg)	140–200	120–160	80–100	200–240	160–200
Daily gain (g)	300–450	250–400	150–250	450–600	400–500
Mature body weight	350–500	300–400	200–250	500–600	400–450

Table 14. Trends in buffalo population in different agro-ecological zones.

Zone	1981	1997	% Change
Wet-zone	155,700	123,900	–20.42
Wet-inter	98,600	65,800	–33.26
Dry-inter	289,300	268,600	–15.08
Dry	354,700	301,206	–15.08
Total	898,300	759,506	–15.45

Source: Department of Census and Statistics.

Table 15. Average herd size and range in different agro-ecological zones.

Zone	Average	Maximum	Minimum
Wet-zone	13.25	69	1
Wet-inter	25.025	242	1
Dry-inter	31.0	138	2
Dry	34.4	152	2
Overall	26.2	242	1

Source: de Silva et al. (1985).

Table 16. Percentage of herds carrying improved breeds in the different agro-ecological zones.

Zone	1985[1]	1999[2]	% Change
Wet-zone	26.5	24.2	–9
Wet-inter	16.8	26.0	+54
Dry-inter	31.8	38.0	+22
Dry	30.25	3.7	+11
Overall	26.3	30.4	+13

[1] de Silva et al. (1985).
[2] Ibrahim et al. (1999).

Livestock Breeding Policy and Organisation of Breed Improvement

Only animals kept in government farms and in a few commercial farms are given identification and data collected on their performance and reproduction. New genetic material is introduced through the importation of live animals and semen mainly by the government.

During the past century, the following breeds were imported to Sri Lanka: Shorthorn, Ayrshire, Santa Gertrudis, Red Poll, Jersey, Friesian (both European and American). The buffalo breeds imported were Surti, Murrah and Nilli Ravi.

Since the 1960s, around 3.5 million inseminations were carried out using both chilled and deep frozen semen, the present coverage of the artificial insemination service is around 7–10% of the cattle population of the country and around 12% of the cow population (Table 17).

Though genetic improvement programs were carried out for over a century, the present production levels are low due to the indiscriminate programs of genetic improvement without giving due consideration to the farmers resource base and the farming system. This has resulted in under-utilisation of the genetic potential of the animals.

The present 'National Breeding Policy Guidelines for Livestock in Sri Lanka,' was published by the Ministry of Livestock in 1994. This document gave recommendations as to the type of breed which should be reared in the different agro-climatic areas of the island. This document is not a legally binding document and the 'National Breeding Committee' which drew up this document has no legal status, even though it still meets from time to time.

The breeding objective does not give details as to the type of animal which should be the final product. The breeding strategy consist of mainly cross breeding programs, using genetically superior breeds so as to upgrade the existing livestock, thereby enhancing production (Tables 18 and 19).

At present, embryo transfer is not practiced and breeder organisations do not exist.

Since the year 2000, the Department of Animal Production and Health has implemented a five-year program on the location, identification, characterisation and the preservation of Sri Lanka's livestock sector biodiversity, within the framework of which, with the collaboration of the Ministry of Forestry and Environment an 'Action Plan on Livestock Sector Biodiversity' is under preparation.

Table 17. Number of artificial inseminations carried out from 1994–1999 in each province.

Province	1994	1995	1996	1997	1998	1999
Western	12,532	13,125	16,064	17,247	17,936	17,500
Central	28,505	35,698	39,501	38,640	41,773	41,850
Southern	3,235	4,716	6,001	6,840	7,519	7,400
North Central	6,103	8,915	10,087	10,041	7,774	7,805
North Western	12,911	14,993	20,118	20,494	22,127	22,580
Northern	7,170	4,561	754	6,117	7,254	7,650
Eastern	660	980	1,084	1,316	1,549	1,605
Uva	6,081	8,558	9,322	10,072	12,547	13,200
Sabaragamuwa	4,295	4,592	5,407	4,651	5,204	5,534
TOTAL	81,482	96,138	108,338	115,418	123,683	125,124

Table 18. Breeding strategy for cattle.

Agro-climatic zone	Production system	Strategy and recommended breeds
Hill and mid country zones	Intensive	Using Holstein Friesians continuous upgrading of present cattle herds and/or Jersey to 75% or more temperate blood levels. Ayrshire will be used as long as available
	Extensive	Upgrading of existing cattle herds using Holstein Friesian and/or Jersey, the blood levels maintained at 50% temperate levels. Ayrshire to be used as long as available
Low country wet zone and low country dry zone	Intensive	Upgrading of existing cattle using Jersey and/or Holstein Friesian and maintain at 50% temperate blood level
	Extensive	Continuous upgrading of existing cattle herds using Sahiwal to 75% or more Zebu blood levels. Sindhi, Tharpakar and Gir will be used as long as available
Coconut triangle zone and Jaffna peninsula	Intensive	Maintaining of 505 temperate blood levels using Friesian and Jersey
	Extensive	Continuous upgrading to 75% or more Sahiwal blood level. Sindhi, Tharpakar and Gir will be used as long as available

Table 19. Buffalo breeding strategy.

Agro climatic zone	Production system	Strategy and recommended breeds
Mid country, low country wet zone	Intensive	Upgrading of the present buffalo herds to pure exotic level using Murrah, and/or Nilli Ravi
Low country dry zone and the coconut triangle		Upgrading present buffalo herds to 50% Murrah, and/or Nilli Ravi. Buffalo used for ploughing in upcountry terrace paddy cultivation not to be upgraded

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Cattle and Buffalo Breeding in Sri Lanka

K.C. Somapala[1]

Abstract

A major proportion of the total cattle population of 1.59 million are indigenous cattle which are small, with low milk and meat production potential. Temperate cattle breeds used as exotics are mainly Jersey and Friesian. Buffalo milk constitutes about 25% of the estimated national annual milk production of about 342 million litres. However, out of the 100,000 litres of milk collected by the national collection grid in the formal market, only 5% is buffalo milk. Emphasis given in the past on buffalo breeding is less compared to that of cattle. Different breeds of river-type buffalo had been imported (both males and female) for breeding purposes in government-controlled farms. The Livestock Breeding Project, functioning under the Ministry of Livestock Development, is planning to initiate milk recording and progeny testing in cattle and buffalo. The national breeding program aims to up-grade existing native buffalo towards Murrah and Nili Ravi breeds, with emphasis on milk production.

SRI LANKA is an island surrounded by the Indian Ocean and only 29 km (by sea) from the southern Indian State of Tamil Nadu. Its total area is 65,609 km^2. It has a maximum length of 435 km and width of 220 km. It has a national population of 18 million in nine provinces composed of 25 administrative districts and has an annual growth rate of about 1.2%.

Twenty-five per cent of the population live in urban areas. Population densities vary between 115 to more than 1300 people per square kilometre. The total agricultural population is about 10 million and it is estimated that 3.5 million are involved with livestock. About 70% of them are rural farmers. Sri Lanka has a mountainous area in the south central region which rises to a peak of 2500 m.

The total estimated agricultural land is about 2 million hectares, which is about 30% of the total land area. This area mostly consists of small holdings, and, of those, 90% are of less than 2 ha.

This combination of elevation, temperature and rainfall gives rise to a number of climatic zones. There are 6 major agro-climatic zones relevant to livestock production, known as the Hill Country Zone, the Mid Country Zone, the Low Country Wet Zone, the Low Country Dry Zone, the Coconut Triangle Zone and the Jaffna Peninsula (Figure 1).

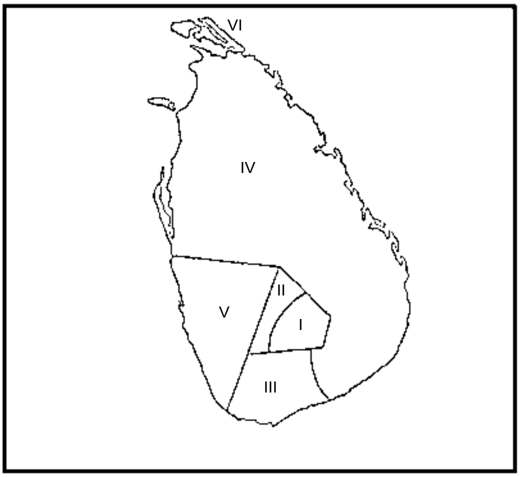

Figure 1. Agro-climatic zones of Sri Lanka: I. Hill Country Zone; II. Mid Country Zone; III. Low Country Wet Zone; IV. Low Country Dry Zone; V. Coconut Triangle Zone and VI. Jaffna Peninsula.

The location and areas of natural grazing for cattle are given in Table 1. The total extent is 655,500 ha. The per capita availability of different meats and milk are given in Table 2. Table 3 gives details of cattle statistics and farming systems by agro-climatic zones.

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Table 1. Natural cattle grazing areas in Sri Lanka.

Location	Hectares
Dry Zone	400,000
Coconut plantations	140,000
Hill Country patna lands	55,000
Fallow paddy fields	30,000
Homestead gardens	20,000
Road sides	5,500
Others	5,000
Total area	655,500

Table 2. Per capital availability of beef, pork, mutton, poultry and milk.

Item	Kg/year	G/day
Beef	1.37	3.76
Pork	0.12	0.32
Mutton (goat and sheep)	0.15	0.42
Poultry	2.54	6.95
Milk	14.05	38.55

The major proportion of the total cattle population (1.59 million) comprises indigenous cattle which are not productive. Temperate breeds used as exotic breeds are mainly Jersey and Friesian. The tropical dairy breed being used is Sahiwal. The synthetic breed used to maintain the crossbred population is the Australian Friesian Sahiwal (AFS). Native cattle are small with low milk and meat production potential. But they are comparatively resistant to diseases commonly affecting other breeds.

Table 4 gives information on the production performance of cross breeds and native cattle.

About 50 years ago, cross breeding through artificial insemination (AI) was begun in Sri Lanka and it now covers about 10% of cattle. Pure Jersey and Friesian breeding is practiced mainly in the mid and up-country regions. In all regions, cross breeding using European and Indian breeds is common, along with up-grading to Sahiwal in the dry zone.

Up-graded stock and crossbreds are better milk producers even though they are vulnerable to

Table 3. Cattle statistics and farming systems by agro-climatic zone.

Agro-climatic zone	Production emphasis	Herd size, breeds	Cattle population
Hill Country Zone	Milk	1–3 animals per unit. High share of European breeds (Holstein, Friesian, Jersey, Ayrshire) and their crosses	132,400
Mid Country Zone	Milk, meat	2–4 animals per unit. European crossbreeds	57,500
Coconut Triangle Zone	Meat, milk	2–10 animals per unit, mainly European × Indian crossbreeds or indigenous Zebu-type (Sindhi, Sahiwal and crossbreeds)	337,900
Low Country Wet Zone	Meat, milk	2–10 animals per unity, mainly Indian breeds (Sindhi, Sahiwal) × indigenous Zebu type	96,000
Low Country Dry Zone	Meat, milk draught, manure	A few more than 160 animals, mostly indigenous Zebu-type (Jersey × local crossbreeds also seen)	916,900
Jaffna Peninsula	Milk, meat	1–4 animals per holding, mainly Jersey crossbreeds and Indian crossbreeds	58,300
Total			1,599,000

Table 4. Production performance of European and Indian breed and crossbreeds and local breed female cattle.

	European crossbreeds	Indian crossbreeds	Local breeds
Reproduction performance			
Age at 1st heat (months)	14–20	16–22	24–28
Age at 1st parturition (months)	26–32	28–34	36–40
Calving interval (months)	13–15	13–15	12–14
Number of calvings	5–7	5–7	6–9
Milk yield			
Milk yield per day (litres)	6–15	4–6	1–3
Length of lactation (days)	300	270	180
Lactation yield (litres)	1800–4500	1080–1620	180–540
Growth and body development			
Birth weight (kg)	25–35	20–25	15–18
Weight at 1 year old (kg)	140–200	120–160	80–100
Daily gain (g)	300–450	250–400	150–250
Mature body weight (kg)	350–500	300–400	200–250

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diseases. A recent survey conducted by the International Livestock Research Institute (ILRI) indicates that the national cattle population is composed of 61% indigenous cattle, 29% crossbreds and 10% purebreds. However, this has to be confirmed by bigger surveys. The growth rate of the national cattle population had a negative trend (–2%) during 1984 to 1994 and the growth rate appears almost static in the following years.

Meat and Milk Production

Beef is predominantly supplied from extensively managed large herds in the dry zone. The supply is supplemented further by surplus males and culled cows from the dairy industry. There is no special program implemented for beef production.

Official estimates reveal that around 190,000 head of cattle are being slaughtered annually. (Not counting the unlicensed slaughter). However, based on information from tanneries, it is reasonably estimated that a total of about 500,000 head of cattle and buffalo (in a ratio of 4:1) are being slaughtered annually, enabling the availability of 60,100 tonnes of carcass weight.

It is estimated that the beef industry returns to the agriculture sector about Rs2 billion per annum, generating significant economic activity.

Total estimated milk production per year is 342 million litres of both cow and buffalo milk (in a ratio of 2:1). About 30% of this production is handled by the formal market which collects about 100,000 litres per day.

Productivity Information

Table 4 shows data on productivity/performance. The crossbred cattle performed better compared to native cattle.

Milk and Meat Marketing

Milk

Milk marketing involves a collection network of primary collection points, chilling centres and tanker transport to processors. There are 250 primary collection points and 129 chilling centres in the formal market milk procurement, and the main stakeholders are the government-controlled Kiriya Milk industries, Nestlé-controlled International Dairy Products Ltd (IDPL) and Nestlé Lanka Ltd (NLL), in addition to a few dairy cooperatives. There are 8–10 small processors also involved in milk collection.

Meat

Meat marketing is controlled by respective local government institutions. Retail outlets are predominantly located in markets which are under the control of local councils. On average, a meat stall sells 3–5 carcasses per day.

The capital, Colombo, has about 80 beef stalls under the Colombo Municipality. About 30% of beef produced is said to be consumed in Colombo. Further details about meat marketing are given in Table 5.

Table 5. Physical characteristics of (slaughter) cattle and buffalo.

Characteristics	Cattle	Buffalo
Average live animal weight (kg)	200	300
Dressing (%)	50	53
Average dressed weight (kg)	100	160
Boning yield (%)	68	70
Average boned weight (kg)	68	113

Genetic and Breeding Programs

Milk recording is practiced in government-controlled farms. There was no field recording program implemented on a long-term basis. Actions are now being taken for milk recording in view of the envisaged Progeny Testing Program. The recording now being practised in the said farms involve Jerseys, Friesians, Sahiwals and their crosses. Bulls selected, based on pedigree and performance testing, were used as semen donors. These were selected from National Livestock Development Board farms.

Imported bulls had been used as semen donors from time-to-time. Fifteen bulls were imported from Australia (Jerseys), Netherlands (Friesians) and Australia (AFS) in 1999. These are being used as semen donors to meet the requirements of DF semen at semen processing centres of the Livestock Breeding Project.

Deep frozen semen also had been imported from time-to-time in the past for the AI program on an ad hoc basis.

The national breeding program is being implemented as per National Breeding Policy, details of which are given in Table 6.

Constraints to Production

National milk production is affected by low farm gate prices, high costs of feed, inadequate procurement and lack of suitable breeding stock.

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In the case of the beef industry, the obvious constraints identified are the ban on slaughter of female cattle and buffalo and the complete ban on the slaughter of buffalo from 1979, lack of an adequate marketing system and lack of modern slaughterhouses.

Buffalo Population

Basic statistics

About 0.72 million buffalo are being reared mainly in the dry zone and the coconut triangle. Herds mostly contain native Suramp type animals. Indian Murrah and Pakistan Nili Ravi are being reared in certain government-controlled farms as purebreds, and crossbreeds of these bred with native buffalo are seen in small numbers in the villages. Another breed, Surthi, which was used in the breeding program, is being phased out gradually.

Native buffalo are considered not productive and crossbreds available in small numbers perform better.

Table 7 gives information on the distribution of the buffalo population in different zones, breeds and production emphasis.

During the period 1993 to 1998, the buffalo population showed a negative rate of growth (0.79 million to 0.72 million) and remained almost static thereafter. Even though buffalo slaughtering is banned, the illicit slaughter nets about 100,000 head annually, producing about 12,000 tonnes of meat.

Productivity

Table 8 provides information on productivity performance of buffalo, both native and crossbreed.

Marketing

Milk

The farm gate price of buffalo milk is higher than that of cows' milk. Payment is made based on fat and SNF content in the formal milk market. In the

Table 6. Breeding strategy for cattle in Sri Lanka.

Agro-climatic zone	Production system	Strategy and recommended breeds
High Country Zone and Mid Country Zone	Intensive Semi-intensive	Continuous up-grading of existing cattle using Holstein Friesian and/or Jersey to 75% or more of temperate blood.
	Extensive	Up-grading of existing cattle using Holstein Friesian and/or Jersey and maintenance of 50% of temperate blood. Ayrshire shall be used as long as available and will be phased out gradually.
Low Country Wet Zone and Low Country Dry Zone	Intensive	Up-grading of existing cattle using Jersey and/or Holstein Friesian and maintenance of 50% temperate blood.
	Extensive	Continuous up-grading of existing cattle using Sahiwal to 75% or more of Zebu blood. Sindhi, Tharpakar and Gir shall be used as long as available and will be phased out gradually.
Coconut Triangle Zone and Jaffna Peninsula	Intensive Semi-intensive	Up-grading of existing cattle using Jersey and/or Holstein Friesian and maintenance of 50% of temperate blood.
	Extensive	Continuous up-grading of existing cattle using Sahiwal to 75% or more of Zebu blood. Sindhi Tharpakar and Gir shall be used as long as available and will be phased out gradually.

Table 7. Buffalo population statistics.

Agro-climatic zone	Production emphasis	Herd size, breeds	Buffalo population
Hill Country Zone	Draught	1–2, mostly native	14,300
Mid Country Zone	Draught	1–2, mostly native	21,000
Coconut Triangle Zone	Milk, draught, meat	2–5, native, Indian breeds, crossbreeds	224,500
Low Country Wet Zone	Draught, milk, meat	2–7, native and some crossbreeds	39,500
Low Country Dry Zone	Draught, milk, meat	4–50, native × Indian breeds, crossbreeds	421,400
Jaffna Peninsula			0
Total			720,700

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informal milk market, buffalo milk is sold at higher prices with fat and SNF tests. This is because of a thriving curd-producing cottage industry. Buffalo milk constitutes about 25% of the estimated national annual milk production of about 342 million litres. However, out of the 100,000 litres of milk collected by the national collection grid in the formal market, only 5% is buffalo milk.

Meat

As there is a ban on buffalo slaughter, there are no licensed buffalo slaughterhouses. However, the illicit slaughter caters for 100,000 head per year. This meat is mixed and sold with cattle meat at the beef stalls and to other certain bulk consumers.

A beef slaughtering and processing industry has not developed in Sri Lanka.

Table 8. Productivity/performance of female buffalo.

	Indian crossbreeds	Local breeds
Reproduction performance		
Age at 1st heat (months)	24–30	24–30
Age at 1st parturition (months)	38–42	38–42
Calving interval (months)	16–18	16–18
Number of calvings	5–7	5–7
Milk yield		
Milk yield per day (litres)	6–7	2
Length of lactation (days)	300	180
Lactation yield (litres)	1800–2100	360
Growth and body development		
Birth weight (kg)	25–30	20–25
Weight at 1 year old (kg)	200–240	160–200
Daily gain (g)	450–600	400–500
Mature body weight (kg)	500–600	400–500

Indian crossbreeds: Murrah and Nili Ravi with local.

Constraints to Production

The role buffalo can play in meat production is affected by the ban on slaughter. Genetic improvement for milk production is affected by the non-availability of studs and an effective AI service. Seasonal breeding and difficulties in heat detection are other constraints to breeding.

Genetics and Breeding Programs

Emphasis given in the past on buffalo breeding is less compared to that of cattle. Only 2% of AI performed annually is on buffalo.

Even through the native buffalo is classified as a swamp type, recent studies have revealed that their chromosome number is the same as that of the river type buffalo (with 50 chromosomes).

Cross-breeding using river types like Murrah and Nili Ravi had been going on for some years. This breeding program depended on natural service and it was limited by non-availability of an adequate number of studs. The performance of crossbreds compared to native buffalo is given in Table 8. Crossbreds show better performance in milk production and lactation length.

Milk recording is practiced only in government-controlled farms which are few in number and involving some 500–700 milch cows.

Different breeds of river-type buffalo had been imported (both males and female) for breeding purposes in government-controlled farms. Deep frozen semen had been imported from time-to-time for the limited national breeding program involving some government-controlled and private herds.

The Livestock Breeding Project, functioning under the Ministry of Livestock Development, is planning to initiate milk recording and progeny testing in cattle and buffalo.

The national breeding program aims to up-grade existing native buffalo towards Murrah and Nili Ravi breeds, with emphasis on milk production. Attempts are being made to provide as many stud bulls as possible on a streamlined bases and to introduce AI using Murrah and Nili Ravi semen. Sri Lankan Breeding Policy guidelines on buffalo breeding are given in Table 9.

Molecular genetics has not developed yet, and no private breeding programs are being implemented to any notable extent.

Table 9. Breeding strategy for buffalo in Sri Lanka.

Agro-climatic zone	Production system	Strategy and recommended breeds
High Country Zone and Mid Country Zone	Intensive	Up-grading of existing buffalo to pure exotic level using Murrah and/or Nili Ravi
Low Country Wet Zone and Low Country Dry Zone	Extensive	Up-grading of existing buffalo and maintenance of 50% exotic level using Murray and Nili Ravi if draught power is required

Current Situation and Development Trends of Beef Production in Thailand

Ancharlie Na-Chiangmai[1]

Abstract

Beef for consumption in Thailand is mainly from local cattle and buffalo. Buffalo and cattle previously were used for working in crop plantations. Consequently, farmers no longer raise cattle and buffalo for working but rather for beef production. Most of the cattle population in Thailand consists of native cattle that the farmers raise extensively. Buffalo breeding, as well as cattle breeding in the village, is generally random mating. The demand for high-quality beef has been increasing due to the change in the socio-economic pattern of the population, such as an increasing standard of living and education. Therefore, the marketing system in the country demands animals that produce heavy carcasses with less fat trims. The animal that is highly fertile and efficient in growth performance is preferable. A selection program which incorporates these two characteristics is suggested when determining which animal to keep for mating to produce progeny in the next generation.

THAILAND, an agricultural country, is situated on the Indo-China Peninsula. The country covers an area of 514,000 square kilometres, lies in the heart of Southeast Asia, roughly equidistant between India and China. It shares borders with Myanmar to the west and north, Lao PDR to the north and northeast, Cambodia to the east and Malaysia to the south. The general weather conditions throughout the country are those of a tropical climate and remains hot throughout the year. Average temperatures are about 29°C, ranging in Bangkok from 35°C in April to 17°C in December. There are three seasons: the cool season (November to February), the hot season (April to May), and the rainy season (June to October). The annual rainfall is about 1500 mm/year. The Kingdom is geologically divided into four regions: North, Northeast, Central and Southern. These regions are divided into 76 provinces. Thailand has many major rivers including the Mekong and the Chao Phraya, and has shores on both the Indian and Pacific Oceans.

With the human population of 60 million, 75% are farmers who live in the rural area where agriculture offers the major source of income and livelihood. They earn their living from agricultural production using a mixture of plants and livestock. The country is renowned as a big rice producer and the major rice exporter to the world market. Rice is the major plantation of the country (Table 1) and there are also other cash crops such as cassava, corn and soybean. In the southern part of the country where the weather is more wet and humid, rubber trees and oil palm trees are the main crops. Plants provide 60.96% Gross Domestic Products (GDP). Livestock production is an integral part of the crop production system and earned the country 9.69% GDP (Table 2). The decreasing GDP of the livestock sector has been affected by the decrease in GDP of cattle, buffalo, swine and eggs, while poultry, dairy products and others increased (Figure 1).

In Thailand, beef for consumption is mainly from local cattle and buffalo. Buffalo and cattle previously were used for working in crop plantations. Presently, the change in the socio-economic pattern of the local farmer has gradually been absorbed by modern technology; these animals are being replaced for their draught power by machinery. Consequently, farmers no longer raise cattle and buffalo for working but rather for beef production. The demand for red meat increases at the rate of 0.17 per year. The meat marketing system in Thailand is quite extensive and can be classified into three different groups of consumers. The first group is the local consumer with

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Table 1. Area of holding by type of crop cultivated (1993).

Total of agricultural land	Rice	Field crops	Rice and other crops	Pasture	Others
112,831,127	42,330,385	9,297,983	43,443,157	284,421	17,475,181

Unit: Rai (1 Rai = 0.16 ha).

Table 2. Gross domestic products of agricultural sector.

Descriptions	1996	1997	1998	1999*	2000*	Increasing rate
Agricultural sector	329,522 (100.00%)	324,797 (100.00%)	336,679 (100.00%)	341,253 (100.00%)	349,093 (100.00%)	1.66
Plants	200,863 (60.95%)	196,342 (60.45%)	206,274 (61.27%)	210,132 (61.58%)	215,736 (61.80%)	2.13
Livestock	31,923 (9.69%)	30,137 (9.28%)	29,141 (8.66%)	29,940 (8.77%)	30,295 (8.68%)	–1.11
Fisheries	47,708 (14.48%)	50,804 (15.64%)	50,384 (14.965)	50,042 (14.66%)	50,223 (14.39%)	0.88
Forestry	3593 (1.095%)	3080 (0.95%)	2729 (0.81%)	2398 (0.70%)	2202 (0.63%)	–1.57
Agricultural products	37,236 (11.30%)	36.211 (11.15%)	39,709 (11.79%)	40,242 (11.79%)	42,000 (12.03%)	1.40
Agricultural services	8190 (2.49%)	8223 (2.53%)	8442 (2.51%)	8449 (2.49%)	8637 (2.47%)	1.40

Note* Estimated.
Source: Agricultural Statistics and Economics Bureau, Bangkok, Thailand.

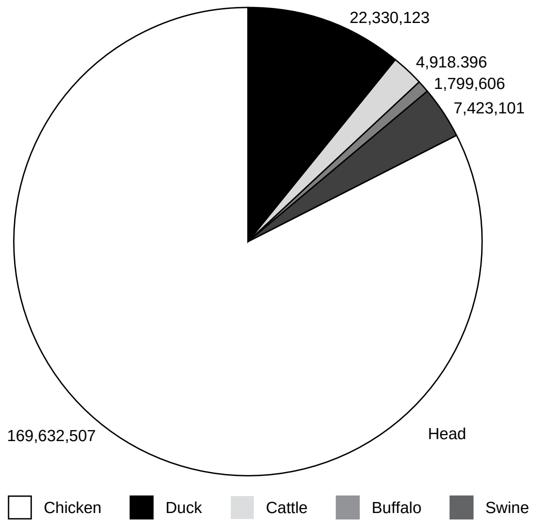

Figure 1. Livestock populations in Thailand.

95% of the whole population who buy fresh meat from the local market. The second group is the meat processing industry, and the third is the consumer group who buys good quality meat for particular purposes, for example, for restaurants. The meat sold for local consumption and to the meat processing factories is normally from the abattoir where the live animals are purchased directly from the villagers. Those animals are priced per head by individual appearances, depending on the size of the animal. The fresh meat is sold to the butcher at the prices per kg carcass weight and then to the local consumers; thus, the price is doubled from the original. Good quality meat can now be bought in general markets.

Cattle population

Most of the cattle population in Thailand consists of native cattle that the farmers raise extensively. In the past five years, the beef cattle population has decreased at the rate of 13.41% per year (Table 5). The largest area that the cattle are raised in is the north-eastern part of the country, which has 39% of the total.

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Buffalo population

Buffalo are indigenous to Thailand and are well-adapted to the poor conditions, especially in the northeast part of the country. They are capable of utilising agricultural waste products or low quality feed to convert into meat while also providing manure for use as a fertiliser. Excess animals are also sold when necessary for extra income. However, the industrial revolution has had a strong impact on the farmers lives. Now farmers no longer raise their animals due to lack of plantation land, unpredictable weather and potential damage to crops. Young village people, who traditionally supervised the animals during the day, can also change their careers to non-farm enterprises that are quite often city-based. All of these factors influence the reduction in the buffalo population. Thus, beef production in the future cannot be sustained under traditional practices, but rather fewer animals are raised without planning for long-term sustained production.

There are approximately 20,000 buffalo herds that consist of 6–20 buffalo per herd. Many buffalo belong to the merchants who buy young buffalo from the villagers and feed them until they reach market weight (450 kgs). The buffalo meat marketing system in Thailand is quite extensive. The local consumer will buy fresh meat from the local market. However, the biggest market of the buffalo meat is the meat processing factories. Meat sold for local consumption and the processing factories is normally from the abattoirs where the animals are purchased directly from the villages or from local live animal markets. At these markets, animals are priced by individual appearance depending on the size of the animal. It was stated by Chantalakhana (1999) that the buffalo population in Thailand had declined at the rate of 3.8% annually since 1984 due to high slaughter rates, scarcity of farm labor and grazing areas, the increasing use of small tractors and low market prices. The buffalo population from 1995 to 1999 and the negative growth rate are shown in Table 6.

Table 3. Statistics of slaughtered livestock in Thailand.

Year	Cattle	Buffalo	Swine
1995	626,596	158,805	3,911,804
1996	597,548	158,517	3,723,679
1997	440,756	124,875	3,834,566
1998	389,303	98,993	3,741,348
1999	375,665	104,104	3,643,254

Source: Anon. 1999b.

Table 4. Statistics of imported meat.

Year	Beef (kg)	Mutton (kg)	Turkey (kg)
1995	1,400,943	44,967	15,667
1996	1,164,622	91,183	30,894
1997	1,655,334	43,433	31,947
1998	2,021,265	104,335	42,674
1999	1,785,300	167,718	82,296

Source: Anon. 1999b.

Table 5. Number of cattle in Thailand (1994–1999).

Year	Central	NE	North	South	Total
1995	1,812,960	2,890,894	1,972,643	932,571	7,609,068
1996	1,424,988	2,546,397	1,385,340	868,496	6,225,221
1997	1,266,558	2,372,352	1,068,433	887,465	5,594,808
1998	1,097,157	2,102,957	911,740	752,419	4,863,373
1999	1,041,442	2,286,973	900,025	689,956	4,918,396

Source: Anon. 1999c.

Cattle and buffalo production system at village level

The production system for beef animals centres mainly on the local village. The farmers generally keep the animals in temporary housing in the back yard. While farmers have less use of cattle or buffalo for work, they still keep the animals in the family as part of their tradition. Breeding units per family average about 3.25 females. Buffalo draught power was commonly up to 60% in the low land rain fed area where farm machinery could not been used. There is less use of draught animals for work now but rather for meat production which is a secondary product in the traditional production system. Both cattle (most are native and Brahman-native crossbred) and buffalo are capable of utilising agricultural waste products or low quality feed to convert into meat. They are tethered in the harvested rice field, on the roadsides, or uncultivated land so that feed is dependent upon the availability of native grasses in areas where they are allowed to graze. In general, buffalo nutrition depends mainly upon rice straw and rice stubble. Other crop residues such as corn stalks, cassava chips, or kenaf leaves sometimes provide substantial sources of roughage during the dry season. When the cropping season begins during the rainy season, most of the land is used for rice or crop plantations. The animals are tied up for almost four months and fed only rice straw with scarcely any extra concentrate or mineral supplements.

Buffalo breeding, as well as cattle breeding in the village, is generally random mating. During the planting season, the animals that are tied up for almost four months and are not available for mating. They are then grazed together in the paddy fields after the harvesting season when mating occurs. In some areas, where large paddy fields are available during summer, the number of females in a herd may be up to 30–50 heads with few bulls roaming together. Most of the small farmers do not maintain their own breeding bull because the number of breeding cows per family is very small. Only 8% of the farmers keep bulls for mating in their own herds. At the small farmer level, approximately 80% of mating occurs naturally in the field. Artificial insemination in the buffalo in the farmer herds is limited due to poor accuracy of heat detection and the large distances animals are kept from an AI centre. Very few farmers keep breeding bulls and traditionally castrate the excess number of male buffalo in order to make them more easily controlled and to avoid the fighting among them. However, the artificial insemination approach in cattle is quite successful, especially using the exotic breeds such as Charolais, Simmental or Holstein Friesian.

National Buffalo Genetic Improvement Program of beef cattle and buffalo

In order to select beef cattle, including crossbred and native cattle, and buffalo for sires and dams, a central performance testing procedure was initiated. Weights and body conformation at various ages were recorded and used as a tool for selection. Selection criteria included high growth rate and general appearance.

Since 1996, the Australia Centre for International Agricultural Research (ACIAR) has introduced a new technology for genetic evaluation of swamp buffalo under the project Genetic Improvement of Thai Beef Cattle and Buffalo. The Thai BREEDPLAN software has been programmed to analyse data recorded since 1991 up to the present time, to identify superior animals and to define the genetic and phenotypic trends over years. Estimated Breeding Values (EBVs) of animals were obtained from the analyses using Best Linear Unbiased Prediction (BLUP) methodology in a multi-trait animal model for across-herd evaluation. The information that was held in standard format on paper for over two decades has been entered into a national computerised database. This database is used to calculate genetic parameters used in the on-going genetic evaluations and improvement programs (Myer et al. 2000). Since 1998, beef cattle and buffalo estimated breeding values in various traits have been used to select genetically superior animals for breeding and develop appropriate strategies for maximising the dissemination of the genetics of these superior animals (Na-Chiangmai and Allen 2000).

Table 6. Number of buffalo in Thailand (1995–1999).

Year	Central	NE	North	South	Total	Growth rate
1995	228,023	3,009,063	398,562	74,413	3,710,061	–12.18
1996	153,892	2,258,494	236,686	70,602	2,719,674	–26.69
1997	135,618	1,911,639	187,095	59,586	2,293,938	–15.65
1998	109,806	1,614,867	171,371	55,024	1,951,068	–14.95
1999	97,879	1,503,176	151,134	47,417	1,799,606	–7.76

Source: Anon. 1999c.

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Genetic improvement program at small farmer level

Many projects aim to improve the productivity of buffalo in the villages have been approached by various research institutes. Socio-economics has been taken into account as buffalo are classified as part of the farmers tradition and rite. An open nucleus breeding scheme (ONBS) has been introduced by the Department of Livestock Development. The farmers are requested to record basic data of their animals. The DLD officers also give advice and follow up with the villagers. The village data are recorded on the central database and analysed using the Thai BREEDPLAN genetic evaluation system.

The future development of beef cattle and buffalo

The Ministry of Agriculture and Cooperatives has approached the objective strategies on future beef industry development as follows:

1. To increase the efficiency in the Government sector for breeding development and relay it to the farmers systematically.
2. Extend the results of basic animal health programs in collaboration with the promotion of the use of good sires, with participation of the farmers in the development by setting up group support organisations.
3. As native cattle and swamp buffalo farming is mostly practiced in the Asian region, there is a constraint on research to build up the technology in this direction. It is therefore necessary to support researchers to be able to work in this area and employ high technology towards swamp buffalo production.
4. Expand the ability of the existing national database to record adaptation information alongside pedigree and performance information. The initial focus of this work will utilise the historical pedigree data combined with the adaptive traits of faecal egg counts, body temperature and health data as these measurements become available.
5. Research molecular genetics in collaboration with universities and related agencies, including the development of a DNA gene bank so that future DNA molecular work can access that of adaptation genetics. This gene bank will be developed in collaboration with the DLD gene bank initiative (under the Asian Development Loan Project).
6. Help sustain the in situ conservation of native cattle and buffalo genetics by helping to establish sustainable buffalo (and native cattle) production systems at the village level while providing improved genetics using the government breeding program.

Conclusion

The demand for high-quality beef has been increasing due to the change in the socio-economic pattern of the population, such as an increasing standard of living and education. The marketing system in the country demands animals that produce heavy carcasses with less fat trims. The animal that is highly fertile and efficient in growth performance is preferable. A selection program which incorporates these two characteristics is suggested when determining which animal to keep for mating to produce progeny in the next generation.

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Cattle Breeding in Vietnam

Vo Van Su[1] and Dang Vu Binh[2]

Abstract

Vietnam's cattle population amounts to about 4 million head, of which 50% are used for draught power. Breeds used for draught are Vietnam Yellow Cattle (VYC) and Laisindh (a cross-breed of VYC and Red Sindh) and Red Sindh. The buffalo population is about 2.9 million. There have been some attempts to cross the Vietnamese buffalo cow with the Murrah bull to create a hybrid, which can produce meat and milk. As a result of the crossing, the crossbred had a larger body size than the local buffalo, it grows faster and the milk yield is also higher.

VIETNAM is a Southeast Asian country of about 300,000 km^2 and with a population of 78 million. Farmers represent 75% of the population. In 1998, the gross output of livestock production was 16,467 billion VND (constant price in 1994), of which the gross output of pig production was 10,567 billion VND, or 64.17%. Poultry production was only 2835 billion VND, or 18.2% of the total. The non-meat products gross output was 2438.4 billion VND in 1998, or 15.05% of the total value.

The total output of the livestock production sector is only 17.6% of the gross output of total agricultural production. Swine production provides 77% of total meat produced followed by chicken at 15.2% and beef at 7.6% (Table 1).

Cattle and buffalo populations have increased slightly from 1997 to 1999 (Table 2). However, these increases are proportionally less than for pigs and poultry.

Meat consumption and production (as exports are only 1% of total product) per capita is low, although it has increased by 4–5% from 1990 to 1999 (Table 3). However, beef production/consumption per capita has remained virtually stable over this same period.

Land for grazing is restricted (326,000 ha or 1.1%) because of the small areas available and the fact that nearly 95% of cultivatable land is used for agriculture and forestry. Farmers graze animals in small areas such as the borders of land used for other purposes. Buffalo and cattle are often hand-fed at home.

Table 1. Annual animal production (1990–1999).

	Animal product	Unit (tonne)	1990	1995	1996	1997	1998	1999
1	Animal live weight	'000	1007	1332	1498	1503	1593	1712
	Pigs	'000	729	1007	1076	1154	1227	1318
	Rate	%	72	76.1	75.4	76.8	77	77
	Poultry	'000	179	197.1	213	226.1	239	261.8
	Rate	%	16	15	15.1	15	15	15.2
	Beef	'000	119	118	119	122.7	128	131.7
	Rate	%	11	8.9	8.8	8.2	8	7.6
2	Eggs	Billion pieces	1.89	2.82	3.08	3.16	3.22	3.44
3	Fresh milk	'000	20.1	20.09	27.8	31.2	36.6	39.6

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Table 2. Livestock and poultry population from 1997 to 1999 (in 1000 head).

Item	1997	1998	1999
1. Pig:			
Population	17,635	18,132	18,880
Growth rate	4.22	2.82	4.15
2. Cattle:			
Population	3904	3987	4063
Growth rate	2.76	2.11	1.91
3. Buffalo:			
Population	2943	2951	2955
Growth rate	–0.35	0.26	0.15
4. Poultry:			
Population	160,550	166,382	179,323
Growth rate	6.04	3.63	7.78
Of which:			
—*Chicken:*			
Population	120,567	126,361	135,760
Growth rate	6.91	4.81	7.44
—*Duck:*			
Population	39,983	40,021	43,563
Growth rate	3.51	0.09	8.85

Source: State Statistics Department, 1999.

Table 3. Average of animal product per capita.

SNo.	Average/ capita	Unit	1990	1995	1999	Annual growth rate (%)
1	Animal lwt.	kg/capita	15.21	17.99	22.43	4.44
	Pig	kg/capita	11	13.6	17.28	
	Poultry	kg/capita	2.52	2.66	3.43	
	Beef	kg/capita	1.69	1.73	1.72	
2	Egg	piece/capita	28.6	38.16	45.1	5.24
		kg/capita	1.44	1.91	2.26	
3	Fresh milk	mL/capita	140	282	520	16.44

Draught Cattle Breeding

Some 4 million cattle belong to farmers and 50% use them for draught purposes. Breeds used for draught are Vietnam Yellow Cattle (VYC), Red Sindh and Laisindh (a cross-breed of VYC and Red Sindh).

Buffalo breeding

Population and production trends

The buffalo population is about 2.9 million (Table 4). Buffalo numbers are declining in the delta areas where mechanisation is gradually replacing the buffalo for working the fields. The buffalo is a swamp type that can be used for meat consumption. While this is not official government policy, quantities do in fact reach the Hanoi market where buffalo meat is often confused with cattle meat.

Table 4. Buffalo population and meat production in 1999.

Ecological regions	Population		Meat production	
	(1000 head)	Growth rate (%)	(1000 tons)	Growth rate (%)
North West	1345	2.16	14.4	1.78
North East	365	4.14	4.1	4.99
Red River Delta	173	–5.01	3.9	5.87
North Central Coastline	668	1.82	7.0	2.23
South Central Coast	127	0.37	1.7	3.63
Central Highlands	51	2.62	1.1	12.34
North East South	147	–2.53	9.5	8.70
Mekong River Delta	75	–13.83	4.4	–6.21
Whole country	2955	0.39	46.2	1.42

Source: State Statistics Department, 1999.

Some characteristics of buffalo production in Vietnam

The Vietnamese buffalo is small. The weight of the adult on average is about 340 kg, the new-born calf about 22–23 kg. In the post-weaning period from 6 to 12 months of age, calves grow slowly, the growth becoming faster after 12 months of age. Normally, the body weight of the weaned calf at 12 months is about 150 kg. Because of the faster growth after one year, it is possible to reach 250 to 300 kg at 24 months. This growth pattern means that we can develop a technology of fattening heifers for meat.

The fertility rate of the buffalo herd, on average, is low at about 30%. In some hilly and mountainous areas where buffalo have to do less work, the reproductive rate may reach 36%, while it is only 20% in the deltas as a result of the work stress.

The age at first calving is about 48 to 52 months. The calving interval is from 27 to 30 months. The oestrus season is concentrated in the months of October and November, which means that the calving season is during the months of September and October the next year.

There have been some attempts to cross the Vietnamese buffalo cow with the Murrah bull to create a hybrid which can produce meat and milk. As a result of the crossing, it was seen that the crossbred had a larger body size than the local buffalo, grows faster and the milk yield is also higher. On average, the crossbred F1 can give from 700 to 800 kg milk/ lactation.

Beef Cattle Breeding

Main beef resources are Yellow Cattle (80%) and Laisindh (Vietnam Yellow Cattle and Red Sindh) (about 15% of total cattle population).

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Vietnam Yellow Cattle are well adapted to the climate as well as local feeding conditions. However, it has very poor performance in terms of beef production. Its body weight at maturity is about 160–170 kg, with carcass percentage of 30%.

Moves to provide a new breed for beef production began in 1920 (during French rule) with the crossing of Yellow Cattle with Red Sindh imported from Pakistan. Body weight of this cross increased by 30–35%, meat production increased by 5–8% and draught power increased by 120% compared to Vietnam Yellow Cattle.

Foreign beef is imported for use in better class restaurants and bars.

Much research as been conducted to improve the performance and quality of beef in Vietnam. During the period 1989–1991, under the Beef Cattle Development Project—VIE/86/008, some thousands of the crosses were made. Some of these experiments are detailed in Table 5.

Table 5. Weight comparisons of cross-breeding experiments of cattle at three stages of growth.

Crosses	Body weight at 12, 18 and 24 months (kg) (with feed supplement at 6 month of age)
Zebu × Laisindh	123 – 200 – 224
Brown Swiss × Laisindh	134 – 212 – 242
Charolais × Laisindh	155 – 216 – 263
Santa Gertrudis × Laisindh	158 – 200 – 242

In recent years, experiments have focused on fattening and economic comparisons of beef breeding in different economic zones. Some new crosses were introduced, such as Brahman or Sahiwal and Laisindh.

From 1993, experiments were conducted again to find the best combination (F1) of Laisindh with *Bos taurus* breeds, as detailed in Table 6.

Table 6. Performance details for cattle in cross-breeding trials conducted from 1993.

Crosses (F1) of Laisindh with:	Body weight at 12, 18 and 24 months (kg) (with feed supplement at 6 month of age)
Charolais	173 – 232 – 296
Limousine	139 – 170 – 265
Hereford	146 – 179 – 247
Simmental	168 – 250 – 315
Red Sindh	123 – 156 – 212

It is recognised that not much progress has been achieved so far, although some good results have been obtained from the research. The cause is probably a lack of good extension work.

It was an unusual event when a southern Vietnamese company decided to import 15,000 Droughtmasters and others from Australia for fattening in order to supply southern markets. It appeared that the 'gate to Vietnam was opening' in this field.

Dairy section

Vietnam is one of the countries in Southeast Asia that is interested in the Holstein breed. Since 1990, the average per capita milk consumption has increased from 0.47 kg to 3.70 kg in 1995, 5.0 kg in 1998, 5.7 kg in 1999 and approximately 6.0 kg in 2000. Currently, milk consumption is 430,000 tonnes which is mainly consumed in the cities of Hanoi and Ho Chi Minh. Demand for milk is greater than production. Milk production was only 42,000 tonnes in 1998 rising to an estimated 45,000 tonnes in 1999. Only 10% of demand can be produced in the country with 90% being imported from other countries. Due to this increasing demand, breed improvement is the strategy chosen for improving milk production nationwide.

Holstein Friesian

Holstein Friesians were imported from Cuba (originally Canada) from 1968. Now they are kept in two highland provinces: Mocchau highland (Son La province) and Lam Dong (near to Dalat) highland—both are about 1000 metres above sea level. They number about 1500, and milk production is about 4000 kg/lactation, with 3.5% fat.

This breed is well managed with a recording system introduced from Cuba. Now the records are managed with software called 'Vietnam Dairy Management' issued by Ministry of Agriculture and Rural Development.

Vietnam dairy cattle

Vietnam dairy cattle are a cross of Holstein Friesian and Laisindh.

In the year 2000, there were almost 40,000 head of dairy cattle. However, the average lactation increased from 2330 kg in 1995 to 3500 kg in 2000. This improvement was a combination of technical progress in dairy husbandry, combined with an improved breeding program.

There are approximately 5800 dairy farms and most of them, while small to medium scale, account for nearly 95% of dairy cattle. Farm management is

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rather well established. Consequently, the reproductive performance is as follows: the age at puberty is 15–22 months, first calving age is 26–40 months, calving interval is 400–480 days, the onset of heat postpartum is 60–120 days. Nearly 95–98% of herds use artificial insemination instead of natural mating.

The dairy industry began when the Nestlé, Foremost and Vinamilk companies were established and made numerous improvements in milk processing. Almost 90% of milk production for Hanoi and Ho Chi Minh City is produced by these companies. The dairy products include fresh milk, pasteurised milk, sweet and condensed milk, milk cake, butter and yoghurt. Although it is cheaper to produce condensed and sweetened milk from imported non-fat milk powder than from fresh milk, companies are encouraged to use the local milk in these early stages of dairy development.

The development plan for the dairy population in the new century (from the year 2000 to 2010) should see the number of dairy cattle increase from 32,000 in 2000 to 80,000 in 2005. By 2010, the population of dairy cattle should be about 185,000 head. This plan will result in improved dairy production in the near future.

A small part of this population, mainly on government-owned farms, is managed using 'Vietnam Dairy Management', a software package developed in Vietnam for recording and monitoring dairy herd and milk production information.

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Invited Papers

An Overview of BREEDPLAN

Jack Allen[1]

Abstract

BREEDPLAN is a modern genetic evaluation program for beef cattle and buffalo. It was developed in Australia to integrate the pedigree and performance information available on an animal population and then calculate Estimated Breeding Values (EBVs) that can be used for ranking animals within that population. Using Best Linear Unbiased Prediction techniques, the analysis is a multi-trait, full animal model that simultaneously allows for fixed effects and pedigree relationships. Up to 17 commercially relevant traits are analysed including components of calving, growth, carcass and fertility. Accuracies of the estimates are also provided as an indicator of how much information was available to calculate the EBVs. BREEDPLAN development is ongoing and further traits for feed efficiency and temperament will be available by the end of 2001 and allowance for genetic markers will be investigated in 2002.

THE Agricultural Business Research Institute (ABRI) established the National Beef Recording Scheme at the University of New England (UNE), Armidale Australia in 1973. The pedigree and performance records submitted by commercial and seedstock cattle producers since then has become the research database used to develop the modern genetic evaluation program called BREEDPLAN.

The BREEDPLAN analytical procedure was developed by the Animal Genetics and Breeding Unit (AGBU) based at the UNE. AGBU is a joint venture between the UNE and New South Wales Agriculture. Funding support for BREEDPLAN was provided by Meat and Livestock Australia from funds supplied through slaughter levies on the Australian beef industry.

Beef Cattle Societies and breeders in Australia, New Zealand, North America, Canada, Thailand, Philippines, Hungary, United Kingdom and Argentina record their pedigrees and performance information on BREEDPLAN systems. Six breeds (Angus, Hereford, Shorthorn, Simmental, Limousin, South Devon, and Salers) combine data cross Australia and New Zealand to run their breed evaluations. The Murray Grey breed runs a single analysis for Australia, New Zealand, North America and Canada.

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The Model

BREEDPLAN is based on an 'animal model' which incorporates multi-trait analysis procedures to produce EBVs for recorded cattle for a range of traits. BREEDPLAN uses an advanced form of the analytical procedure known as BLUP—Best Linear Unbiased Prediction. The BLUP analysis of performance information relies heavily on the accurate and complete recording of pedigree details on the animal as well as the performance measures. The performance measures supply the quantitative variation of the performance of the animals while the pedigree information enables comparisons across management groups, years and herds free of environmental differences. This also allows the model to calculate genetic trends over the years of recording.

The Growth, Fertility and Carcass traits (Table 1) plus birth weight and gestation length are analysed in a single, multi-trait analysis. The Calving traits are analysed separately in a model that caters for the non-continuous (categorical) scoring of calving ease and the continuous measures of the gestation length and birth weight traits.

These traits are described in more detail later in the text.

New traits are generally developed within research projects with co-operating producers supplying pedigree and performance information at a production level to support this research.

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Table 1. The 17 traits for which EBVs are currently available in BREEDPLAN.

Calving	Growth	Carcass	Fertility
Calving ease direct Calving ease daughters Gestation length Birth weight	200-day weight 400-day weight 600-day weight Mature weight 200-day milk	Carcass weight Eye muscle area Rib fat depth Rump fat depth Intramuscular fat % Retail beef yield %	Scrotal size Days to calving

Characteristics of the data (genetic and phenotypic variances and correlations, heritabilities) are evaluated to generate the genetic parameters required to run a BLUP analysis. These genetic parameters may vary between breeds and populations. Table 2 outlines the genetic correlations and heritabilities used in the Australian Brahman analysis.

Pedigree

A mandatory requirement of a pedigree recording system is unique, unambiguous and permanent identification of the animals in the system. The identification needs to be unique across animals both within the herd as well as between herds and years.

General methods of identification are ear tags of various shapes, sizes and colours, hide brands, ear tattoos and, more recently, electronic—either as implants under the skin or fixed in small ear tags. Each method has its own inherent advantages and disadvantages. Whatever the method, it is important that the identification is unique and permanent. Ear tags are prone to loss, so it is important to have a secondary system as well so that lost ear tags can be replaced with the same identification.

It is important to identify sire, dam, date of birth and sex for the performance recorded progeny. While it is possible to do sire only evaluations, genetic gain is maximised if dam details are recorded. It is also important to know the breed of the parents as well as the age (birth date or birth year) of the dam. The breed of the parents is important for considering any heterosis effects while the calf's own performance is adjusted for the age of the dam when the calf is born. Young dams (especially 2 year old heifers) usually have lighter weight calves than when they are older.

The maximum advantage of BLUP evaluation systems is gained by having layers of pedigree/performance breeding where performance calves are born to performance recorded parents, etc., thus allowing better estimates of genetic relationships in the current animal population.

Traits

Traits analysed in BREEDPLAN cover four areas of vital importance to bull breeders and commercial producers. These are **Calving, Growth, Carcass and Fertility.** This allows a balanced approach to designing efficient breeding programs for various environments and to target specific markets.

Not all breeding programs require all traits to be measured. For example, birth weight and calving ease are not generally recorded in extensive grazing systems. However, it is important that as many progeny in the breeding system are measured as is possible. The EBVs are unlikely to truly reflect the genetic potential of the animals or the herd if animals are selectively recorded (e.g. only record the 'best half' of the herd). Whole herd recording is particularly important for analysing the days to calving trait.

Calving traits

Calving Ease (Direct and Maternal), **Birth Weight** and **Gestation Length** are analysed in a model that allows for the categorical scoring of calving ease (Table 3) and the continuous measures of birth weight (kgs) and gestation length (days).

While management practices will influence the level of observed dystocia in a herd, the underlying genetic potential for dystocia can be monitored using the EBVs.

Growth traits

EBVs can be calculated for weights at the following ages: Birth; 200, 400, 600-days and Mature (weight of the cow when her calf is weaned).

Animals' weights are adjusted to standard ages of 200, 400 and 600-days based on the following age ranges at measurement:

Age Range	Trait
80–300-days	200-day weight
301–500-days	400-day weight
501–900-days	600-day weight

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Table 2. Heritabilities and genetic correlations for Brahman cattle.

Trait name	Gest Len	Birth Wt	200-D Wt	400-D Wt	600-D Wt	Mature Wt	Carcass Wt	Rib Fat	P8 Fat	EMA	RBY%	IMF%	Scrotal Size	Days To Calve	200-D Milk
Heritability:	L	H	L	M	H	M	M	L	L	L	M	L	H	V	V
Gestation length		L	–V	–V	–V										
Birth weight			–V	M	M	L	L						V		
200-day weight				H	H	M	M	–V	–V		–V	–V	V		
400-day weight					H	M	H	–V	–V	V	–V		V	–V	
600-day weight						H	H	–V	–V	V	–V		V	–V	
Mature weight							M						V	–V	
Scan hfr p8							V	H	H	V	–M	L			
Scan hfr rib							V	H	H	V	–M	L			
Scan hfr ema							M			H	L	V	V		
Scan hfr imf								L	L		–L	H			
Scan bull p8							L	H	H		–L	L			
Scan bull rib							V	H	H		–L	L			
Scan bull ema							M	V	V	H	L	–V	V		
Scan bull imf								V	V		–V	H			
Carcass weight								–V	–V	V	–V	V	V		
Rib fat									H		–L	L			
P8 rump fat											–L	L			
Eye muscle area											M	–V			
Retail beef yield %												–L			
Intramuscular fat %															
Scrotal size														–V	
Days to Calving															
200-day milk															

Heritabilities: V = very low (<.15) L = low (<.3) M = medium (<.4) H = high (.4+)
Correlations: V = very low (<.2) L = low (<.4) M = medium (<.6) H = high (.6+)—indicates negative correlation blank = near zero

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Table 3. Calving ease scoring system.

Blank/0	1	2	3	4	5
Not recorded	No difficulty	Easy pull	Hard pull	Surgical	Posterior presentation

Both the 200-Day and 400-Day weights are partitioned into the growth (direct) and milk (maternal) components and a single milk EBV is calculated for each animal.

Note that this is an 'indirect' measure of the dam's milk based on the maternal influence of the cow on the calf's weight at 200 and 400-days. We do not actually measure the milk production of the cow (as you would in a dairy herd).

Mature cow weights are an indication of the growth pattern of animals and their suitability for the production system. Larger mature weights may be desirable for animals being fed to later ages for particular markets. However, smaller cows are likely to require less feed for maintaining their body condition and may therefore be more easy to get back in calf under periods of limited feed.

Fertility traits

BREEDPLAN EBVs for the male reproductive trait **Scrotal Size** (circumference) and the female trait **Days to Calving** are available if suitable data has been recorded.

Male calves are measured at about 400-days of age for the circumference of their scrotum. Research has shown that this measure explains some of the genetic variation for fertility between males. From a practical perspective, we also recommend physical examination of the males as well prior to joining to ensure that there as been no physical damage to the reproductive parts.

Days to calving is based on the time between when a cow is first exposed to a bull in a natural mating situation and when she subsequently calves (Figure 1). While this measure includes variation in stages of the cows' cycles and variation in gestation length, it does highlight those cows that consistently get in calf early in the breeding season and calve on a regular basis.

Cows that are mated and do not calve are given a penalty in the analysis. It is also important to identify cows that are joined but are subsequently 'culled for fertility' on the basis of a negative pregnancy test result. All calves also need to be recorded—even if they are dead at birth or die before weaning.

Carcass (scanning)

Five carcass EBVs are available. Information on these may come from ultrasonic scanning of live animals or from direct measures on the carcass at the abattoirs.

Live animal ultrasonic scan measurements are taken by accredited scanners. Accreditation involves both repeatability of the scanner on the same animals as well as between scanners and how well the scan reflects the actual carcass measurements from the abattoir. Accuracy of scanning is checked during accreditation by slaughtering the scanned animals and comparing the abattoir measure against the scan value.

The traits measured at scanning are **Eye Muscle (Rib Eye) Area**, **Rump Fat Depth, Rib Fat Depth,** and **Intra muscular Fat** (marbling).

Abattoir carcass measures analysed are **Carcass Weight, Eye Muscle Area, Fat Depth, Marbling** (usually through a visual scoring system) and **Retail Beef Yield.**

All available scan and carcass information is combined in the analysis to produce the carcass EBVs. These EBVs are usually only reported if the breeder has measured animals for these traits.

Research is also being conducted on meat **tenderness** (shear force test) and **pH** levels.

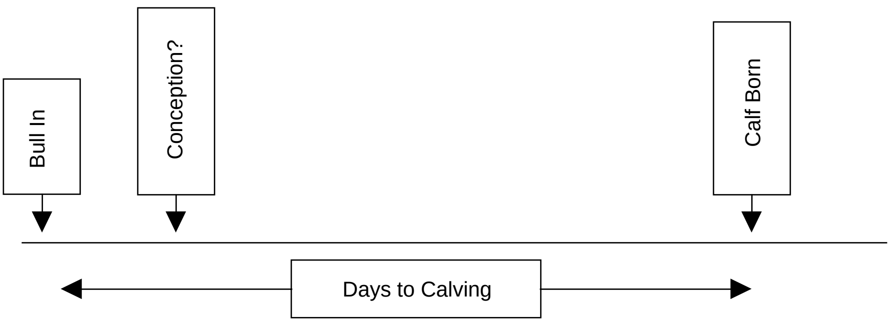

Figure 1. Days to calving.

Developmental traits

Research is currently underway to estimate **Net Feed Efficiency** EBVs based on customised feeders that automatically record the amount of feed an animal eats during a 70-day feeding trial. Trial net feed efficiency EBVs should be available later this year.

Australian research has developed a gene marker (**GeneStar Marbling**) to identify the different alleles of the Thyroglobulin gene in cattle that has a moderate impact on the animal's ability to marble. This data will be incorporated into BREEDPLAN to enhance the calculation of the carcass IMF% EBVs.

Research is underway to review **flight time** (the time it takes an animal to move a set distance while being handled in the yards) as a measure of an animal's temperament and its apparent high correlation to meat tenderness in Northern Australian *Bos Indicus* cattle.

Docility EBVs based on a 1–5 scoring system for temperament will be available later this year.

Establishing new traits

For a trait to be useful in a genetic evaluation, you need to consider the following:

- Is it economically important, or is it a measure of an economically important trait? The basic philosophy is that there will be a cost associated with measuring and recording the trait, therefore you need to get extra income from selecting superior breeding animals (or, as is the case with calving ease, reducing your costs of production) to justify recording the trait.
- Is their variation in the expression of the trait? If there is little or no variation, then there is no potential to select animals.
- Is the trait heritable? How much of an animal's superiority for the trait is passed on to its offspring? The more heritable the trait, the quicker you will be able to move the population towards the favourable genotype.
- Can the trait itself, or a correlated trait, be measured economically? If the trait is economically important but the cost of measuring the trait is larger than the return by selecting superior animals, then the trait may not be worth measuring. This aspect becomes quite complicated in some instances where the returns to the individual herd may be low but the returns to the industry overall may justify the costs.
- Are there correlated effects to other traits (positive or negative)?

Other issues then need to be considered to optimise the results from recording. For example, traits expressed in one sex only, optimum age of measurement to meet age at selection requirements, etc. In order to include the trait into a BLUP type evaluation, you will also need to get estimates of the heritability, variances and covariances with other traits to accurately predict the new EBV.

To encourage further recording of the trait from breeders in general, it is likely that preliminary EBVs will need to be generated (perhaps as a single trait evaluation) until there is enough field data to better estimate the genetic covariances within the recorded population.

Calculating EBVs

One of the fundamentals of the BREEDPLAN analysis system is that animals are only directly compared to other animals that have had an equal opportunity to perform—that is, run under the same management.

The analysis automatically divides the information into herd/year/sex groups as well as by similar ages (called age slicing). The data is adjusted for age at weighing and the age of the dam. Twins and Embryo Transfer calves are also segregated from other animals.

The breeders of the animals also define their own management groups based on when they measure animals as well as by management-group-codes that they can input into the system.

The EBVs become meaningless if the **contemporary group** structure is incorrect.

The differences in performance of animals within a contemporary group are the basis of the BREEDPLAN analysis (rather than the actual values measured). The pedigrees of the animals in the contemporary group are then used to compare animals across contemporary groups which may be in other years, sex groups, herds or even countries. Within a herd, both sires and dams are important genetic links. However, it is mainly sires that link herds together and usually through the extensive use of AI sires.

EBVs rank animals in the population based on the variation in performance of the animal compared to other animals in the population. The proportion of this variation that is passed on to the animal's offspring is called the **heritability** of the trait. This proportion is a population estimate and varies between traits (Table 2). The higher the heritability, the more of an animal's superiority is passed on to its offspring. Hence it is easier to make genetic progress with more heritable traits. Conversely, the lower the heritability, the more reliant the analysis becomes on correlated traits and pedigree information.

Most traits are the result of the interaction of many genes. Some of these genes also impact on more than one trait. The relationship between traits is estimated using the pedigree and performance information and

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are expressed as **genetic correlations** (Table 2). From these estimates we can expect that an animal recorded for one trait will have a certain level of performance in another related trait.

Genetic correlations range from +1 through zero to –1. Zero means no correlation and approaching ±1 means a higher correlation. Negative correlations mean that as one trait increases, the other trait decreases. This can be both a good or bad thing just as a positive correlation can be either good or bad. Table 2 outlines the range of correlations for BREEDPLAN traits for Brahman cattle and shows the inter-relationships of measuring one of the traits and its potential effect on other traits.

From Table 2 we can see that increasing 600-day weight in a breeding herd is likely to increase birth weights as well because birth weight and 600-day weight have a moderately positive genetic correlation. Notice that this is a positive correlation but produces a result that most cattle breeders would not like. Hence, to increase 600-day weight and either maintain or reduce birth weights you will need to measure both traits and select those animals that have good 600-day weights but low birth weights. We call this ‘bending the growth curve’ because, on average (but not always) animals with high 600-day weights are likely to also have high birth weights.

Notice that there is a small negative correlation between scrotal size and days to calving. While small, this is a good correlation (from a cattle breeder’s perspective) because with increasing scrotal size there is a tendency towards decreasing days to calving (which is what we want).

Correlations between traits play an important part in calculating EBVs for traits that are not actually measured on the animal itself at the time of calculating the EBVs. It is the correlated effects and the influence of an animal’s relatives that allows BREEDPLAN to calculate EBVs for say 600-day weight when an animal’s weaning weight is submitted. However, actually measuring the animal will give a more accurate EBV and allow you to identify the animals that ‘bend the growth curve’ and make them more suited to your breeding program.

Genetic correlations are also used to relate traits that are more measurable to production traits that are difficult to measure. For example, increasing scrotal size/circumference itself is of little economic importance—once a bull is physically capable of serving a cow then larger testicles may not actually get any more cows in calf under low mating loads. However, research shows that progeny from sires with larger scrotal size EBVs are more fertile than progeny from sires with low scrotal size EBVs. Similarly, birth weight and gestation length are used to help estimate calving ease.

Accuracy

By definition EBVs are an estimate of an animal’s breeding value that can be used to make breeding decisions about the animal. Its true breeding value is never known, but is approached when large numbers of progeny have been measured. The estimate is made from analysis of all the information that is available on the animal, both its individual performance and that of its relatives. Clearly the more information that is available the more **accurate**, or reliable, the estimate will be.

The calculation of **accuracy** of an EBV is complex and takes into account the following points:

- The heritability of the trait—traits with higher heritability provide more information from a single measure than those of low heritability
- Contemporary group size—larger contemporary groups tend to be more useful than small groups. In particular, single animal groups are of no benefit. Also, contemporary groups where only one sire is represented is also of limited use in the analysis and provides no useful information on the sire. To gauge the usefulness of a sire’s progeny in calculating EBVs, determine the sire’s Effective Progeny Number (EPN) in the contemporary group:
  $EPN_{sire} = [Prog_{sire} (Prog_{total}—Prog_{sire})]/Prog_{total}$
- Genetic correlations between the trait for which an EBV is being calculated, and the other traits measured, will marginally increase the accuracy of the EBV.
- The amount of other information already available on its parents and relatives prior to measuring the calf is a base from which the calf’s own performance information is added. In fact, in the case of the Milk EBV, sires and calves can only get their information from their relatives. The expected performance of the progeny of two parents can be estimated based on the EBVs and Accuracies of the parents. The progeny is expected to have an EBV equal to half of the sum of the sire and dam EBV for the nominated trait:
  i.e. $EBV_{calf} = (EBV_{sire} + EBV_{dam})/2$
  The Accuracy of this prediction is equal to:
  $Acc_{calf} = \sqrt{[(Acc_{sire}^2 + Acc_{dam}^2)/4]}$
- The amount of performance information available. The accuracy of an EBV will change as more performance information relating to the animal (or its relatives) is analysed. Whilst performance records from relatives such as half sibs (brothers and sisters) do increase the accuracy, substantial increases in accuracy are only realised when progeny records are added.

Accuracies are an indication of how much information was available to calculate the EBV. Irrespective

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of accuracy, EBVs have an equal chance of going up as of going down as more information is added. Table 4 outlines guidelines for interpreting accuracy values.

As a general rule, animals should be compared on EBVs regardless of accuracy. However, where two animals have similar EBVs the one with the higher accuracy could be the better choice, assuming other factors are equal.

When you need to choose a single sire that will perform to expectation, choose a sire with both the desired EBVs and high accuracy for the traits of importance. The higher accuracy means there is less chance that the EBV will change as more information becomes available (for example, if you need a low birth weight sire to join to heifers).

However, if you can afford to sample a number of sires then you should consider choosing sires with the best EBVs for the traits of interest with little regard to accuracy. Even though the individual EBVs of these bulls could change, their average EBV will not. You can expect that EBVs for 1/3 of the bulls will in fact be higher than first estimated—thus you have a greater chance of finding a real herd improver for the target trait. Of the other bulls, EBVs will remain steady for 1/3 and decrease for the other 1/3.

Crossbred Animals

EBVs can be calculated for cross bred animals as long as the data base provides information on the breeds of the animals and their parents and the levels of heterosis or hybrid vigour is known or can be estimated from the data for the traits being record.

In simple two breed breeding programs, the crossbred data can be sub-grouped by breed. However, this becomes complicated as the crossbred animals are used for breeding. A better approach is analysing the crossbreds and purebreds in a single analysis while allowing for the estimated levels of heterosis in the various traits. To do this properly, you will need to performance record the progeny of crossbreds and purebreds simultaneously in the same contemporary groups for a range of sires.

Selecting Animals across Environments

Under some situations, animals may perform differently to expectations in one environment compared to another. Australian research has shown that sires may re-rank based on their progeny born in a temperate environment compared to the progeny born in a harsh tropical environment. This is not surprising considering the different types of parasites and nutrition encountered between the environments.

In general, the more similar the environments (climate, nutrition, management, parasites, etc), the more likely that an animal will perform to expectations in a new location. Conversely, if you need to select animals from a different environment, then you are probably better to look at animals from a harsher environment from where they will be used.

Genetics and Management

EBVs are another tool for cattle breeders to use to produce animals that better target their markets. Similarly, breeders will use various management practices to help achieve this aim as well. Genetics and management are complimentary and both require measurements of the results. Changes in management strategy (e.g. pasture improvement, grazing strategies, culling procedures, etc.) need to be measured/monitored to evaluate the benefit (or otherwise) of the change (e.g. calf weights, growth rates, etc.). Much of this information is also required for a genetic evaluation.

EBVs can be used not only to select superior animals genetically for the primary traits of interest,

Table 4. Interpretation of accuracy ranges.

0–40%—Very low	EBVs should be considered a preliminary estimate. They could change substantially as more performance information becomes available. (They are, however, still the best estimate, with an equal chance of rising or falling).
41–60%—Low	Useful for screening 'best bet' animals. Still subject to substantial changes with more information, particularly when the performance of progeny are analysed. This is the likely accuracy range for most calves being selected as replacement breeding stock.
60–75%—Moderate	Medium accuracy and includes some progeny information. Becoming a more reliable indicator of the animal's value as a parent.
75–95%—High	High accuracy and unlikely that the EBV will change much with the addition of more progeny data.
95%+—Very High	Very high estimate of the animal's breeding value. However, the EBV may still change if substantial numbers of progeny are recorded—particularly from unrelated herds.

but also can be used to monitor secondary traits that are of little current interest but may become more important later on. For example, selection for higher 600-day weight EBVs may cause an increase in birth weights. Hence, while a herd is not experiencing calving difficulty at present, monitoring birth weight while selecting for higher 600-day weights is a good insurance policy.

Extension, Research and Development

Most genetic evaluation programs are a result of scientific research and development supported by field data. As these programs become more accepted in the industry, further research is required to support and develop these initiatives. It is therefore extremely important that genetic evaluation systems be seen as an evolving process rather than a goal that, once achieved, further development is not required.

BREEDPLAN has access to the results of significant levels of research done on the Australian beef industry. This research is largely funded by beef producers who pay a slaughter levy into an industry fund that is then used for research and market development. In the 12 months to June, 2001, these cattle levies amounted to $AUD38.7 million.

Genetic evaluation systems not only require support on the evaluation level, but also at the user level. Education of the producers in both collecting information in an unbiased and complete manner is extremely important. Once the EBVs are produced, it is also extremely important to understand what the EBVs mean and how to use them to maximise genetic progress. Both bull breeders and bull buyers need to be educated in this area. Use of producer demonstration sites and examples of field data are useful tools. Such sites can also demonstrate 'best management practice', etc. as well as genetic improvement techniques.

It is also very important that the researchers talk and listen to the producers to ensure that research efforts are focused on industry requirements. There is no point developing evaluation systems that are impracticable to implement or for traits that the producers are not interested in.

Starting a Recording System

Initiating a recording system is reasonably straightforward as long as a few basic guidelines are followed.

Ensure that you have permanent, unique and unambiguous identification on your animals. The identification should be simple and compatible with computer recording (i.e. only use numerals and alphabetic characters). A successful system is to use a 30-letter herd identifier (e.g. ABC), 2-digit year code (e.g. 02 for year 2002) and 4-digit calf number within the year drop (e.g. 0034). Hence, the animal's ident would be 'ABC020034'.

Avoid using existing brands if they are not computer compatible. For example, imported animals with brand diagrams should be re-tagged to give them an identification that is computer compatible and visible to animal handlers. Do not rely on people 'knowing' what the computer identification is for this animal.

Set up a computer database as early as possible and ensure the information is loaded onto the database as it is collected. Use the computer to check the data that are recorded and fix errors as soon as possible. The longer the time from collecting the information to finding errors, the harder it is to fix the problem.

Only add 'correct' data to the database. Do not guess pedigrees, birth dates, etc. If the information is not collected correctly, then do not use it in the database. Also, do not store default values on the database—only recorded information. Let the analysis routine use its own default values (e.g. missing birth weights, birth dates, etc.) if it needs to. Overall, default values in databases reduce the integrity and usefulness of the database for evaluation purposes.

Scientists should spend time with the people who routinely handle the animals and explain what information needs to be collected and **why**. They will also need some training on defining contemporary groups and handling animals as a mob rather than as individuals. In village breeding programs, there also needs to be discussion on controlled mating and ensuring the pedigree of the resulting calves.

For breeding programs, it is important to define the standard management practices, production environment and target market(s). This is done by the scientists in consultation with the animal breeders so that production systems and breeding objectives can be defined that are applicable to the breeders.

Having defined the breeding objectives, the traits to be recorded can be finalised and the recording system can focus on what is important in the production system. The recording system should be focused not only on analytical requirements, but also should focus on management and information requirements. Basic statistical information, cow lists, average weights, etc. should be just as accessible as the EBVs.

It takes time to build up databases. However, participating herds need information back to maintain interest in the program. Therefore, initial analysis of the data may simply give basic results back to participants until there are enough data to do a more sophisticated analysis. Also, use the database to monitor the progress of the breeding program towards the breeding objectives and continue to liaise with the breeders to discuss how they feel about the program and its results for their animals.

Genetic Conservation and Molecular Genetics

The data used for genetic improvement are also a valuable resource for genetic conservation purposes. Whether it is to simply monitor pedigree relationships and levels of inbreeding or is linked to more sophisticated results of molecular genetic DNA sequencing and distance mapping, the database is a valuable tool.

The value of the pedigree data significantly increases when integrated with phenotypic performance details as molecular information can be quantified against actual performance. In some cases, the phenotypic data can indicate the presence of a major gene that can focus the direction of molecular genetic research.

Selection indexes

More sophisticated analyses of breeding objectives can be done with selection index theory. Selection indexes combine the economics of the production environment with the genetic variation expressed by the animals to rank animals on profitability for the specified production and market combinations.

Selection indexes become more worthwhile where many economically relevant production traits are analysed (e.g. fertility, calving, growth and carcass quality). In Australia, a software package has been developed that evaluates selection indexes for user specified production and market environments. The package is called **BreedObject** and is routinely used to calculate indexes for the major breeds in Australia.

Further details on BreedObject can be obtained off the web site http://www.breedobject.com.au/.

Access to Information

Information is only useful if it is available to be used. Advances in technology delivery mechanisms have enabled relatively cheap information delivery systems.

ABRI supports a number of web-based animal/performance enquiry systems for its clients. These are maintained separately from the production databases for security reasons, but are updated on a weekly basis to provide quick and easy access to the breed Society information system. Hence, breeders can use the system to look at sale bulls, check EBVs, locate members, sort animals on EBVs and indexes, etc.

Examples of these systems can be found by going to the ABRI web page (http://abri.une.edu.au/) and following the links to International Livestock Register and then Beef Cattle.

Beef Cattle and Buffalo Data System

Ek Vitoonpong[1] and Michael Rush[2]

THE Department of Livestock Development (DLD) has been raising beef cattle and buffalo for selection and breeding improvement for more than 30 years. Growth performance testing of the cattle and buffalo has been carried out in two central testing stations: cattle in Mahasarakam Livestock Breeding Station and buffalo in Lampayaklang Livestock Research and Breeding Centre.

The Animal Husbandry Division (AHD) is responsible for recording and collection of all the data that has been reported by breeding centres and stations throughout Thailand. The reports include:

1. number and sex of new born calves;
2. body weights and measurements recorded at:
    a. birth,
    b. weaning,
    c. at 1 year old,
    d. and at 1.5 years old;
3. breeding records;
4. sales and prices received for animals;
5. animal health records;
6. numbers of animal deaths.

All of these reports were filled in on paper forms designated by the AHD. They have all been difficult and time-consuming to collect, edit and utilise for either data analysis or summarisation. They have also needed significant space for their safe storage.

In 1995, a database system was established under the project 'Genetic Improvement of Thai Beef Cattle and Buffalo' sponsored by the Australian Centre for International Agricultural Research (ACIAR) in collaboration with the Agricultural Business Research Institute (ABRI) of the University of New England (UNE) and the DLD.

Two computer programs have been used: Herd Magic (Saltbush Agricultural Software) for storage of on-farm databases of animal breeding records, animal performance details, and farm management data; and BREEDPLAN (based on software developed by the Animal Genetics and Breeding Unit (AGBU)).

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BREEDPLAN is a program run on Alpha chip workstations for storing and analysing the combined information from the 'Herd Magic' on-farm PC systems.

Establishment of the Databases

Step 1—Design of the recording system

Every station under the AHD collected all reports either from old documents or researchers and a meeting was set up to design animal tag structure and farm code.

Animal tag

Herd Magic tag format is composed of 8 characters, 5 numeric characters, followed by 3 alphabetic. The 5 digits consist of 2 digits for Buddhist Era year and the other 3 digits for consecutive number (ID or brand) of animal and the last 3 letters for farm code. For example: 43008TAK is the animal born in 2543 B.E (2000 A.D), number 8 from farm Tak. As Herd Magic uses unique Animal Tags as the default sort for all of its screens and reports, this type of Ident allows for the quick sorting of animals in Year of Birth order, Tattoo Order, and mostly in Date of Birth order.

BREEDPLAN format

Identifications begin with farm code and followed by Tattoo ID and year of birth, that is TAK 8/43 is the animal born in 2543 (2000), number 8, from farm Tak, the same animal as above. This type of ident allows us to be able sort and select upon a specific herd of origin when the animals are on the central database.

Observation codes

Beef cattle		Buffalo	
B	at birth	B	at birth
W_2	at weaning (200 days)	W_3	at weaning (240 days)
W_4	at 400 days	W_6	at 600 days
W_6	at 600 days		

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Step 2—Training staff and loading back data

After training station staff in the use of Herd Magic, each of the station's historic data was recorded in the program. The information that has been collected falls into the categories of either Pedigree or Performance details.

1. Pedigree: Animal ID, sire and dam, sex, breed, birth date, breeder code, twin, by ET, and joining/ mating details plus any other appearance details of the animal, e.g. colour and horn.
2. Performance details include any observed measurements such as weight and body measurements (hip height, body length and heart girth) at birth, weaning and yearling and scrotal size at yearling. There are other facilities to record other performance details as required for research purposes.

Step 3—Data corrections

After recording all up-to-date data, the breeding centres and stations send a backup of Herd Magic to the AHD every month. The AHD checks the data for any problems and data inconsistencies and informs the stations or centres to make corrections and send it back to the AHD the following month. At the start of the project, the AHD checked every detail of each database, but, at present, as the AHD has corrected all the previous data, they are now placing emphasise on new records of animals and new measurement/ performance data. This change was made as station staff gained greater confidence and experience in the use of the program, and also as the focus of the ADH staff changed to include the adding of the data to the central Alpha database.

Step 4—Central database establishment

Data are extracted from Herd Magic by the AHD staff in Bangkok and is then loaded into one of the three databases in the Alpha workstation computer.

3. Buffalo;
4. Cattle of exotic breeds (mainly Brahman);
5. Thai indigenous cattle.

This has created a central database for all DLD-owned cattle and buffalo. As animals are transferred from one research or breeding station, it allows the lifetime recording of production and performance. It also allows ADH staff to monitor performance of animals across all their stations as well as to monitor inventory and production statistics.

Step 5—Calculation of the EBVs

About every 6 months, GROUP BREEDPLAN data analyses are performed across the central database system to produce EBVs (estimated breeding values), genetic trends and phenotypic trends for each of the three databases.

Step 6—Utilisation of the EBVs

AHD sends the result of BREEDPLAN analyses (EBVs) to the on-farm Herd Magic systems in the breeding stations and centres using EBV download disks. The EBVs are then used for farm management purposes, especially in bull selection and breeding herd management. Herd Magic also has the added advantage of being useful for on-farm management decisions. The data can be utilised for farm management with ease and convenience using reports available in the program:

1. Decision of culling of non-fertile dams;
2. Summary of animals on the farm inventory;
3. Selection of weaners and animals at 400 days;
4. Report of average daily weight gain (ADG).

Figure 1 outlines the flow of information available through the integrated recording system. As well as having electronic recording at each of the 22 research and breeding centres, these centres also contribute to, and have access to, the results of the national genetic evaluation campaign. Herd management at the centres has improved as well as giving researchers access to the information and allowing them to contribute to the information in the database.

Obstacles and Challenges in Pedigree Recording

As was expected, the addition of such a large amount of historic paper-recorded data was not without difficulty. Several problematic areas included:

- Imported animals with overseas brands and farm codes that did not fit the preferred DLD computer ident coding system. Most imported animals were recorded on the paper data with a hand-drawn brand and a brand number. This hand-drawn brand had to be converted into a computer ident, three characters in length eg ψ 471 would be UFK 471. These brand idents had to be converted many times as the animal was recorded with progeny each year, or appeared in the mating records. Different people sometimes converted the brands in different ways, or the paper records were not clear or consistent, leading to the creation of more than one animal ident for the one actual animal.
- In the past, some DLD stations recorded animals of a different colour, sex, or breed with the same tattoo or brand numbers. This was acceptable for on-farm use with paper records, but led to confusion when the records were added to a computer in a combined database or used by other stations as two different animals were given the same computer ident.
- Some farms from both overseas and in Thailand use numbers of more than four characters in length.

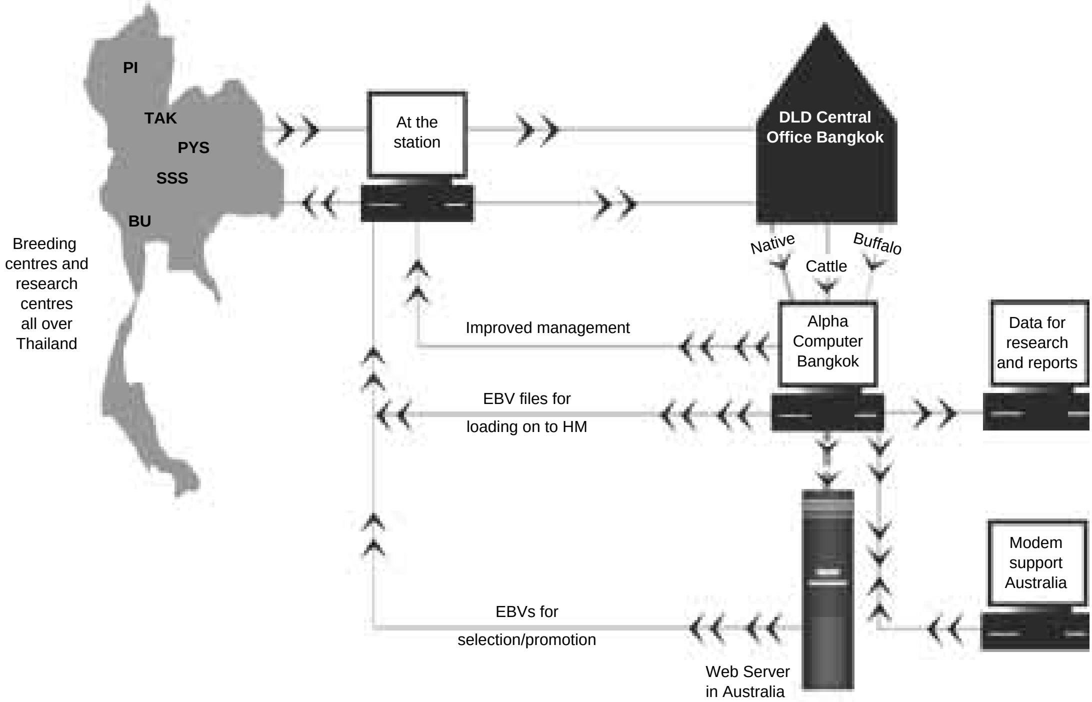

Figure 1. Flow of information under the Project.

Therefore, some brands had to be truncated to fit into the DLD preferred restriction of eight characters for ident length. Therefore, JDH 1124 had to be changed to either UJD 112 or UJD 124, either of which may have also been imported as well.

Obstacles and Challenges in Performance Records

Some historic records were found to be incorrect, from either a transcription error or data were missing or repeated for another measurement. Sometimes, recording dates were recorded as DD/MM/YY and other times as MM/DD/YY, also leading to confusion.

Other data were missing as the paper records had been lost or destroyed over the years. This highlighted the importance of adding these records to a computer system in an efficient, timely and unambiguous manner where they could be safely stored for future use.

New and Future Activities

Recently, the AHD has initiated the recording of Thai indigenous cattle data in the villages. This new move is designed to record base level performance with the view to using selected village cattle in effect as multiplier herds and demonstration 'best practice' farms.

The DLD database represents a significant proportion of nucleus breeding operations in Thailand; however, the addition of data from larger private farms is also a way of increasing the size of nucleus breeding operations without significant cost to the DLD. The DLD will operate the database for the Thai Brahman Breeders Association which is in effect a subset of the existing system.

Conclusion

The project has successfully captured, stored and analysed more than 20 years of breeding and performance records on Swamp Buffalo, Beef Cattle and Native Cattle. On-farm databases have been successfully created to the benefit of station management and research.

Estimated Breeding Values have been used for the selection of animals to go into an elite-breeding herd for cattle and swamp buffalo.

The flow of information between the DLD and the breeding stations has now been changed into a feedback mechanism, rather than compulsory reporting. The national genetic evaluation incorporates research, government and private recording and is a valuable resource for further genetic improvement and research projects.

Buffalo Development in Thailand

Jintana Indramangala[1]

Abstract

Most buffalo in Thailand are classified as swamp buffalo, traditionally raised by small farm holders for multi-purpose roles complementary to crop production. Buffalo farming essentially has three functions: farm integration; insurance, capital formation and income; and food production. These three functions impact on the sustainability of small farmholders. Environmental factors determine the status of buffalo production in farming systems and influence the type of farming carried out. It is evident that human influence and socioeconomic factors related to the location of the production also have a decisive impact on the goals of livestock production. Population growth, local economic development and increasing urbanisation have created a demand for buffalo products. As a result, the number of buffalo in Thailand is sharply decreasing. This paper discusses the buffalo development system in Thailand, with particular reference to sustainable buffalo production systems.

Population and Distribution

ACCORDING to FAO statistics (1996), Thailand had the fourth largest buffalo population after India, China and Pakistan. Although the world buffalo numbers are increasing at about 1.3% annually, Thailand, has had a sharp decline in numbers (Table 1).

From 1994 to 2000, numbers decreased from 4.2 million to 1.7 million head which equates to an annual percentage change of –13.8%. The distribution of buffalo is predominantly in the Northeastern part of Thailand which accounts for about 83% of the total, particularly in the south of Northeastern, namely, Ubonratchathani, Surin, Burirum, Roi-et and Yasothon provinces (Table 2). There were 517,941 families farming buffalo and 88% of them were living in the Northeast (DLD, 2000).

Production System

Most of Thailand's buffalo production could be referred to as backyard, subsistence production, involving smallholders in remote areas. There is a great variety in forms of husbandry and management techniques from region to region and even from farm to farm. These variations in husbandry and management are a result of the natural conditions of the grazing area, the crop production system, and the lifestyle and economic framework of the farmers. Knowledge about assessing the suitability of animal species in different environments has been passed down through generations of farmers. In the Central region, where the land is generally flat with good soil fertility, there is a higher population density and a high level of mechanisation in the irrigated paddy fields. Even so, the number of buffalo is quite large. The buffalo do not graze on specific pastures, nor are

Table 1. Number of buffalo in Thailand by year (1994–2000).

Year	Total	Annual change	
		±head	%
1994	4,224,791	–579,355	–12.1
1995	3,710,061	–514,730	–12.2
1996	2,719,674	–990,387	–26.7
1997	2,293,938	–425,736	–15.7
1998	1,951,068	–342,870	–14.9
1999	1,799,606	–151,462	–7.8
2000	1,702,223	–97,383	–5.4
	Total change		–13.8

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Table 2. Buffalo and householder distribution by region in 2000.

Region	Number			Total head	Number of householders	Head per householder
	Female/male ratio	Male	Female			
Total	2.55	479,220	1,223,003	1,702,223	517,941	3.29
Central	2.52	28,100	70,868	98,968	13,893	7.12
Northeast	2.57	393,797	1,012,645	1,406,442	457,590	3.07
North	2.25	46,280	103,976	151,829	36,554	4.16
South	4.88	11,043	53,941	44,984	9904	4.54

they fed supplements; rather, a more traditional ‘cut and carry’ or tethered grazing system is used. Buffalo production is for generating income and building savings. Animals are sold when the family needs cash.

The Northeast region of Thailand has the most buffalo. This region is generally characterised by poorer soils, less rainfall and only small amounts of irrigation for rice growing. A Department of Livestock Development (DLD) survey of stockholders in the Surin area revealed that the average farmer was of low income, living off a farm with rain–fed rice production and owning 3 buffalo. The farmers priority for keeping buffalo were draught power, manure as fertiliser for the rice fields and as a savings bank against hard times. Hence, meat production per se was not the primary focus of these farmers. From the farmers perspective, sustainable systems are those that have supported their families over many generations. Traditional farming practices are used extensively and generally include daytime grazing (edge of fields, roadsides marginal land, communal grazing areas, etc.) supplemented with rice straw in night corrals. Note that animals are usually supervised while grazing (for confinement and protection reasons) and this has traditionally been the role of children. However, this now conflicts with parents desire to send their children to school and improve their education.

Contribution and Utilisation

While, buffalo production is now of less economic importance in terms of per capita GDP and economic development prospects, its economic importance to individual smallholders is generally underestimated especially by their multi-purpose contributions which ensure food security for the growing population and to increase income of the poor in these subsistence farming systems.

The roles of buffalo in contributing to human needs were discussed by Sansoucy et al. (1993), Peters (1999) and Chantalakhana (2001) and can be grouped into 4 functions:

Food security

Food security can be defined by a combination of balance between availability and need, avoidance of temporary food shortage and nutritional deficiencies and adequate food quality. Buffalo are living manufacturers who transform non-edible human food (such as crop residue, rice straw, and weeds) into high protein food for human consumption. Thus, increased buffalo production may add to food security in several ways. Firstly, many poor farmers will have direct access to more food with lower cost; secondly, increased domestic production will reduce imports and save foreign currency.

Insurance, capital formation and income

This function is most relevant to securing the socio-economic status of the farmers. It can serve as a long-term capital reserve by using local natural resource as long as fodder resources are freely accessible at no charge. However, variable annual rainfall, especially in rain-fed areas, reduces income stability from cropping. Rearing buffalo as a means of a ‘savings bank’ gives some financial security for the household. In addition, sales of progeny or unproductive buffalo and their dung provide direct cash income to the farmers. Therefore, buffalo represent buffer assets (with some security against inflation) which can be realised at any time, adding further stability to the self-sufficiency crop-livestock system.

Farm integration

Farm mechanisation is suitable in some locations and socio-economic frameworks. However, for the smallholder, especially in the Northeast region, buffalo are still used as draught power for preparing paddy fields. The integration of cropping and livestock production makes efficient use of farm waste and crop by-products such as rice straw and weeds, and enables a transfer of such nutrients to cultivated soils using manure. Manure not only provides a direct supply of fertiliser but also improves soil structure

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and pH value of the soil especially in areas which use higher quantities of chemical fertiliser, as in today's rice paddy fields.

Recreation

The buffalo is also considered a friend of the family who is a loveable family member and has many legends about them. Moreover, buffalo are part of many festivals, e.g. 'buffalo racing festival' at Chonburi Province and 'fighting bull' at Samui Island and agrotourism as 'Ban Kwai Thai' at Chaing Mai. International tourists also expect to see buffalo at work in Thailand.

The four functions mentioned here are complementary to each other so that all aspects of sustainability are accounted for; consequently, buffalo should be available for utilisation by future generations.

Breeding Buffalo for Subsistence Farming Systems

One of the important considerations in developing livestock enterprises is obtaining as high a level of efficiency as possible from the animals used. In addition, scientists point out inappropriate comparisons of buffalo productivity with exotic cattle breeds from developed countries, e.g. low growth rate, late maturity and long calving interval, but studies have indicated that their productivity is remarkable high, when compared with exotic breeds under the same harsh conditions. Buffalo infertility has been noted as a major concern. However, it is usually caused by mismanagement, e.g. lack of bulls or neglect by the farmer to give productive females a chance to mate. Moreover, feeding strategies and behavior is important in assessing the suitability of animal species to different environments due to differences in morphological and physiological characteristics associated with diet selection and the rate of passage of fodder through the digestive system.

The most efficient use of low quality roughage

McDowell (1993) and Ligda (2001) have reported that buffalo digest feed more efficiently than cattle, particularly when feed is of poor quality and high in cellulose. No single reason alone explains the buffalo' success in using poor quality forages; rather, it is a combination of reasons that include:

Higher dry matter intake—Buffalo have wide muzzles for rapid intake of feed combined with less selective grazing even on short native grasses. Buffalo generally have a wider range of grazing preferences.

Large gut capacities and a greater degree of fermentation in the rumen—resulting in slow passage of foods from the rumen and therefore higher production of microbial protein.

Rumen bacteria—Poondusit (2001) reported that the numbers of rumen bacteria and fungal zoospores in buffalo were significantly higher than in dairy and beef cattle, while protozoa was significantly less. In addition, the values for ammonium nitrogen in buffalo were higher as a consequence of higher production of microbial protein. This means a higher efficiency to use high cellulose forage, such as crop residue.

Superior ability to handle stressful environments

Some exotic cattle have less tolerance to heat and humidity and so eat less, whereas buffalo in the same field maintain their appetite as long as some shading is provided.

Ponded forage

Buffalo are able to eat underwater forage, such as in a flooded area or in the pond.

Working capacity

The buffalo is a sturdy draught animal. Its body structure, especially the distribution of body weight over the feet and legs, is an important advantage. Its large boxy hooves allow it to move in the soft mud of rice fields, Moreover, the buffalo has very flexible pastern and fetlock joints in the lower legs so that it can bend back its hooves and step over obstacles more easily than cattle. Buffalo have a high capacity for hard work in marshy and flood-prone environments where small tractors cannot work as well. In the Northeast region, buffalo are worked about 5 hours a day. Hence, for small pieces of land of about 3 ha, they may take 10–20 days to plough, harrow and grade the rice paddy field.

Lean meat

Buffalo have leaner meat, 3–5% less fat and less intramuscular fat than cattle (Ligda 2001). Due to their lower fat, buffalo meat is preferable to beef for meatball manufacture and traditional Thai style recipes.

Current Situation, Constraints and Problems

Since buffalo are not just a farm animal or meat producer, breed development has emphasised their suitability for subsistence production systems of smallholders who raise only a small number of animals. Generally, this has not taken into consideration the demand of meat for human consumption and its consequence on animal type.

In Thailand, there is a sharp decrease in the number of buffalo and possible genetic erosion due to heavy slaughtering and exploitation. There were also various lessons to be learned from Government policies, which have changed focus from subsistence farming systems to industrialised systems. The focus has been toward introducing new technology for development to rapidly improve socioeconomic levels and attitudes of farmers to technology. Combined with the Green Revolution, agricultural patterns have dramatically changed and significantly contributed to an increased productivity through the transfer of high yielding plant varieties and livestock breeds to the farmers. Hence, buffalo become a symbol of obsolete farming methods.

Institutional problem

Government policies have affected the utilisation of buffalo and forced their sale by the farmers, e.g.

- Less consideration of buffalo compared to cattle in the livestock development plan. There were no clear extension programs and less research support for buffalo production; hence, production systems are backward within Thai agricultural development.
- The promotion of mechanisation using two-wheel tractors through subsidies and
- credits to farmers over the past two decades. This has promoted mechanisation at the expense of the farmer production.
- The benefits of stock raising are not easily seen by the farmers and planners in the short term.
- Laws and regulations are ineffective to restrict the slaughtering of productive females.

Demand

The demand for buffalo meat is growing fast due to population growth, urbanisation and rising income. The FAO predicts that the demand for red meat (both from cattle and buffalo) will rise from the estimated 6–7.4 kg/h/y in 2000 to 10.1–14.8 kg/h/y by 2001. However, Thailand can currently produce 5.3–6.3 kg/h/y. These predictions are in line with Thailand's current decreasing numbers of buffalo.

Non-sustainable exploitation and consumer demand for red meat has meant that there is heavy harvesting of both young male and female buffalo (even productive females), which has meant that there are not enough productive females to sustain future demand.

Price distortion of cattle over buffalo occurs. Buffalo contribute more red meat than cattle to the Thai market, but their liveweight price is lower than cattle. However, butchers tend to prefer buffalo as buffalo meat and beef sell at the same meat price in the market.

The supply

Smallholders generally do not treat buffalo production as a farm enterprise like the developed world where they are part of an integrated farming system. Conventional Thai production systems tend to exhibit:

Low productivity—especially a low calving rate of about 30% because the owners do not realise that increasing the frequency of calving would have the largest effect on income. The reasons for the low calving rate include lack of a bull because most of the big males are sold before sexual maturity, or even if they have a loan bull, the productive females are unable to have access to the bull because they are in separate grazing areas.

Lack of breeding improvement program—which Chantalakhana (1994) pointed out was due to both a lack of interest among farmers as well as among extension personnel within the loan bull project.

Forced sale of buffalo—due to socioeconomic change, reduced areas of land for grazing, use of mechanisation, off-farm job opportunities and seasonal migration to work (Sukharomana 1991)

So, it has now been generally agreed that people wanting to study and develop buffalo production systems, should identify and diagnose farmers' needs. Problems at the village level need to be defined and should cover the land, the farmer, the animal and the crops in sufficient depth to define constraints in the farming system. However, once the problems and constraints are identified, it is another thing to train the people concerned to overcome such complicated problems.

Swamp Buffalo Development in the Past

Buffalo development in Thailand has been under consideration since 1975. The Department of Livestock Development (DLD), Kasetsart University, Khon Kaen University and the Rockefeller Foundation signed a memorandum of agreement to conduct a joint research program for improvement of a swamp buffalo called 'The National Buffalo Research and Development Centre Project'. It aims at organising resources already existing in the DLD and to have a breeding centre for establishing a swamp buffalo nucleus herd at the National Buffalo Breeding Centre (NBBC) at the Surin Livestock Breeding Station.

There have been various activities in relation to buffalo development which have been carried out at

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a national and international level (Chantalakhana 1994). These include research, education and training, a seminar and a workshop for information exchange, establishment of an information centre called the International Buffalo Information Centre (IBIC) under IDRC support and the formation of an Asian Buffalo Association (ABA).

In addition, there were routine extension programs at farm level, such as the loan bull program, AI service, buffalo health service, buffalo bank and buffalo contest and fair. Until the late 1980s, external agricultural assistance by various agencies decreased markedly while government policies regarding large ruminants were revised, particularly in relation to cattle enterprises (both beef and dairy). However, the buffalo sector has been largely neglected.

Breeding Improvement: the Performance Testing Program

Breeding improvement has been established since 1979, through the 'performance testing program.' A closed nucleus breeding herd was kept at Surin Livestock Breeding Station and a central testing station was located at Lamphayaklang Breeding Station. The breeding objective established since 1981 was to increase the growth rate and then to increase the mature size of buffalo. The breeding herd bulls and cows have been selected through the performance-testing program with an associated aim of improving management, nutrition and health programs. This centre has the capacity to run 300 breeding cows per year. The performance-testing program has a 1-year testing period for each lot. There are 3 lots a year of weaned calves to be selected for this testing and each lot consists of 60–70 weaned calves. The candidate animals were selected by ranking their 240 days weaning weight with good general appearance. At the end of the test period, the animals were ranked for average daily gain (ADG) during test, 2-year adjusted weight, wither height and general appearance. The higher ranked animals were selected and an independent culling level was also based on ADG where the selected male and female should be above 400 and 350 gm/head/day respectively.

The testing procedures have been planned so that they are applicable to smallholders by having similar feeding regimes. The pastures were provided at 1 acre per head and each lot of candidate animals were managed in the same pasture and management condition. The concentrated feed supplied to animals was at the rate of 1% of body weight each day. The concentrated feed had 12% protein and 75% TDN. The top bulls were assigned for collecting semen (distributed to the whole country) and for replacement at the NBBC; the rest were used in farmers' herds. The females that passed the test were used for replacement at the NBBC.

Promising Project for Buffalo Development

Buffalo development has been neglected for a long period, until the sudden downfall of our tiger economy in 1996, when Thailand was faced with a financial crisis. One way to cope with these economic problems is to save foreign currency and promote a self-sufficient economy. Hence, buffalo production gave a good opportunity for this by using buffalo for preparing land and using manure instead of chemical fertiliser. This change in attitude has meant reduced expenditure of the farmer to pay for hiring small tractors and buying fertiliser, both of which we need to import. Moreover, using buffalo for draught animal power may bring back considerable cultural and social links within the community.

Nowadays, the concept of organic farming has grown in importance and become fashionable. Buffalo as draught animal power and for manure is appropriate for this way of thinking. Farmers sometime express their wish to make use of these already more environmentally friendly production methods and convert to organic agriculture. Organic rice farming methods demonstrated at sites such as in Kalasin and Surin Province can result in a higher price to the farmer, by using appropriate product labeling and selling to niche markets.

The new development policy of the government is directed towards participation and the King encourages this. Emphasis towards a new theory and self-sufficienct economy incorporating natural resource conservation and the change in the paradigm for excessive range management has led to a rethinking in the design and implementation of development cooperation. Important instruments to this end are reforms of the institutional framework, support, joint management of resource use, participation by all stakeholders, resource use, decentralisation of management decisions and use of appropriate technologies.

Following the new concept, a farmers' participatory system is practiced by the DLD projects concerning buffalo production. To date, this approach has seen the transition from traditional top-down projects (based on the provision of experts) to people's participation in programs with decentralisation of management decisions to the local community. Therefore, buffalo projects now come from the needs of the grass roots community with Rapid Rural Appraisal methods at the site of the project itself.

Buffalo are deserving of conservation and sustainable utilisation. Various outstanding projects have

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developed with this mind. Unfortunately, achieving results in such a complexity of problems in animal enterprises and rural development is slow. Nowadays, buffalo production emphasises not only the socio-economic and cultural aspects, but also accounts for the high price of buffalo offered to the farmer. Hence, buffalo production includes non-draught aspects with more emphasis on profitable sale.

Breeding improvement: an Open Nucleus Breeding Scheme

Breeding improvement is long term and needs to look at a 20–25 year period. So, the design for the right breeding program is critical. It is likely that draught animal power will become less important, but buffalo for meat consumption might be more important for the next generation. From lessons learned, closed nucleus breeding schemes do not provide enough buffalo bulls to meet the demand of the industry due to limitation of resources and financial support. Therefore, an open nucleus breeding scheme has been established since 2000 with three tiers including:

- the first tier of the pyramid is the 'nucleus herd' in the station farm;
- the second tier is the 'multiplier herds in the model buffalo breeding village';
- the third tier is the 'village herds' around the whole country.

The genetics flow from the nucleus herd through the multiplier herd and then to the village herds by selected bulls and culling females. Upward selection of females from multiplier herds to the nucleus is allowed. Assortive mating with proven bulls in the nucleus herd is practiced.

There are three key decision areas to be considered to make the ONBS beneficial: breeding objectives, genetic evaluation and breeding program design. Buffalo production has traditionally been a subsistence farming system on a smallholder basis. However, breeding objectives are most commonly defined in terms of profit or economic efficiency with no explicit consideration of sustainability and have usually been practiced by livestock production systems in developed countries. However, a breeding objective for sustainability will involve strategic decisions to optimise selection of adaptive and productivity traits. Adaptive traits include fertility in the production environment, survival, which is influenced by disease and parasite tolerance, and efficient use of locally available feeds. As buffalo usually suit these environments, selection has traditionally been done only for production traits (such as growth rate) in the particular environment and to allow natural selection to look after adaptation. However, the relationship between body size and production efficiency in particular environments, especially regarding nutrition where feed quality is poor and sometime seasonal is important. The disadvantage of larger animals requiring higher maintenance may indicate that intermediate body size will produce the greatest return. Hence, the farmers have their indigenous knowledge to select moderate body size of females who can produce a calf every year, while selecting big bulls for draught purposes.

BREEDPLAN is a genetic evaluation system based on BLUP techniques using animal mixed model analysis that allows both fixed and random effects to be fitted at the same time in the model and estimated simultaneously in the same analysis. BREEDPLAN was introduced in 1995 (under ACIAR support) to predict genetic merit of the buffalo (call 'Estimated Breeding Values' or EBVs) and are expressed as the difference between an individual animal genetics and the genetic base to which the animal is compared. With these technologies, measurements in the nucleus herd need to include pedigree and performance information.

Demonstration villages for buffalo conservation and development have been established in the Northeast region since 1999. There are 19 pilot villages in the 19 provinces of the Northeast. There is no blue print for development of the production system. Rather, each site develops its own, based on the local environment, natural resource, socioeconomic and cultural practices, and the traditional farming system of the site. The guidelines for these villages are:

- group the stakeholders together and create a strong civil society with the concept of farmer participation; encourage this by holding regular meetings to elect their own leaders;
- closer links among researchers, extension workers and farmers to analyse and diagnose the results together and discuss the potential of development and allow decision making to come from the community;
- define the efficiency of buffalo production in terms of high output per productive female. Increasing numbers of live calves per female through reducing calving interval will mean the largest income effect; the main challenge to the extension worker who adopts this technology will be to consult with the farmer on how to increase the exposure of the cow to the bull within the constraints that suit to the traditional practice of the farmers in the village;
- advise farmers of other extension work to give incentive to the farmer to utilise buffalo to help alleviate poverty;

- increase knowledge transfer by using techniques that farmers at the village level will relate to, e.g. demonstration site peer discussion.

Role model villages can be established in any reasonably-sized village that has the support of the majority of the community in the village. From the results to date, the number of buffalo in the 19 demonstration villages has increased 22% and numbers of participating householders has also increased 22% in the first year.

A 'Cattle and Buffalo Bank Project' has been established under the initiative of King Bhumipol since 1979. The aim of this project is to donate buffalo to the poor who do not have animals for draught power and as a consequence increase the number of progeny from these animals and pass them on the other people. The fund was established from donations and administered under DLD management.

There is a need for organised extension to persuade people of the value of buffalo and the need to conserve them for sustainable utilisation on the production system:

- organise the National Buffalo Day annually; the main activities are a buffalo contest, organised in order to select the best bulls for donating as loan bulls or semen collection for an A.I. service; conduct academic seminar and indigenous knowledge seminar; technology transfer through posters and demonstrations.
- propaganda through the mass media;
- establish 'The Association of Buffalo Conservation and Development' (ABCD) with the aim to emphasise buffalo conservation and development.

Future Buffalo Development

Buffalo are large ruminants and time is required to implement structural change. It therefore has to be recognised that buffalo projects do not produce quick results for either the donor or the farmer. The following are aspects to ensure buffalo development:

The focus of development should be on the potential and constraints of the target groups. That means ensuring that it addresses their problems, meets their needs and does not overtax the resources available. The best way of making sure of that is by developing the new practices and solutions in conjunction with the users. Target group participation programs and decentralised programs are the preferred approach.

The most incentive for farmers to continue raising buffalo is the sale price. As long as buffalo rearing is profitable, then the total numbers should stabilise and hopefully increase, and consequently be available for use in the paddy field. If so, the farmers will seek to improve their productivity, e.g. by reducing calving interval, maintaining adaptation and increasing the mature weight of sale animals.

A research and development program should be created for farming system research relating to buffalo production. This needs to be a multidiscipline research program to identify, diagnose and design programs which make the greatest impact on farmers' net income, while maintaining and utilising natural resources. This needs to be supported by an extension program conducted in a suitable manner to implement the strategies at the village level.

Government reforms are needed that discourage slaughter of the female herd and reduce the price differential of live buffalo and cattle.

The biotechnology approach with EBVs calculated might be useful for increasing the rate of genetic progress.

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The Thai Indigenous Cattle Breeding Improvement Project

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Abstract

A project has been established by the Department of Livestock Development of the Government of Thailand to improve the genetic quality of indigenous cattle *Bos indicus*. In essence, it follows the Thai BREEDPLAN program introduced from Australia. It is a three-tier program designed to take advantage of and enhance natural characteristics such as high fertility, resistance to diseases that affect exotic breeds, and the ability to thrive in stressful environments. The project is planned for an 8-year period.

THAI INDIGENOUS cattle, classified as *Bos indicus*, have been associated with Thai people for an indefinite period of time (Chantalakana et al. 1971). They have played an important role within agro-culture as a part of a crop-livestock integrated system. In the past, they were important to the quality of life in rural communities in terms of food, bank savings, draught power and agricultural uses.

Thai indigenous cattle are small and have a low growth rate because they have been selected over generations for survival under stressful environments. The result of their adaptation to those conditions is that they have high fertility and a high ability to use low quality roughage. They are raised by grazing on community land and feeding of agricultural by-products. Therefore, their production cost per area is lower when compared to that of exotic breeds that need quality grass (Anon. 1997).

In the past, this prominent characteristic was overshadowed by the large size of imported exotic breeds. In consequence, the indigenous cattle were neglected.

Genetic researchers from various organisations, such as the Society for Advancement of Breeding Research in Asia and Oceania (SABRAO) and the United Nations Environment Program (UNEP), recognised these characteristics and the importance of conserving them for sustainable use in the future.

The Department of Livestock Development (DLD) has been assigned the duty of research and experiments in this field in the agricultural development plan of the country. DLD have therefore launched an indigenous beef genetic improvement project, under the responsibility of the Animal Husbandry Division (AHD). Since 1992, the project has purchased cattle from farmers for breeding improvement, as shown in Table 1.

Table 1. Numbers of indigenous cattle for breeding improvement in DLD stations/centres.

Year	Sire	Dam	Station/centre	Region
1992	10	100	Ubonrachatani	Northeast
1995	10	100	Nakornsithamarat	South
1998	20	100	Payoa	North
2000	8	200	Payoa	North
	4	100	Chaiyapoom	Northeast
	4	100	Nongkwang	Central
	8	200	Krabi	South
	8	200	Thepa	South
Total	80	1300		

Cattle are categorised in four lines by area, i.e. Northeast, North (Kow Lumpoon), South and Central (Klang). There is no genetic information on whether each line is different. The breeding objectives of the lines focus on raising cattle suitable for subsistence smallholder conditions, such as fertility, meat and growth, adaptation and increase of the family income of the farmers. The 1999 statistics of the DLD (L.E.D. 1999) revealed that the total population of beef cattle in Thailand was 4,635,741. This consisted of 2,981,381 head of indigenous cattle distributed throughout Thailand and 33,258 head of Kow Lumpoon cattle, a separate breed indigenous to

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the northern part of Thailand. Animals that show improvement in the stations and centres of the DLD will be distributed to farmers to use in the improvement of their cattle.

Breeding Objectives

The project objectives are:

1. To study the economic traits of the lines in order to develop them for sustainable use. The study will focus on fertility, growth and adaptability in stressful environments.
2. To distribute cattle to farmers for conservation in terms of genetic diversity.

Selection traits

The traits for selection to achieve the breeding objectives are measurements according to the BREEDPLAN genetic evaluation system (Graser et al. 1987) as shown in Table 2.

Table 2. Selection traits of indigenous beef cattle.

Breeding objective	Selection traits	Herds
Fertility	Scrotum circumference, calving interval, days to calving	Nucleus, multiplier
Meat and growth	Weight and body measurement at 200, 400 and 600 day, carcass percentage (ultrasound)	Nucleus, multiplier
Adaptation	Rectal temperature, faecal egg count, tick count	Nucleus

Breeding Structure

The breeding structure is open nucleus, with replacement stocks for the nucleus population selected from both the nucleus and the multiplier population. This leads to a two-way flow of genes. The structure is divided into three tiers: nucleus, multiplier and production herds respectively. Thus, animals are allowed to move in all directions between the nucleus and multiplier (or commercial) herds. Most often, it will be females that are moved between the tiers. The breeding structure and action plan of open nucleus breeding are shown in Figures 1 and 2.

Tier 1: Nucleus herd

The nucleus herd is genetically elite across DLD's stations/centres throughout the country. The herds comprise 52 sires and 1300 dams. The primary function of the nucleus herd is to produce elite animals according to the breeding objective and to distribute them to multiplier units. The selection criterion is the Estimated Breeding Value (EBV).

Sire replacement: select only from nucleus herds.

Dam replacement: mostly from nucleus herds and select the best from the multipliers.

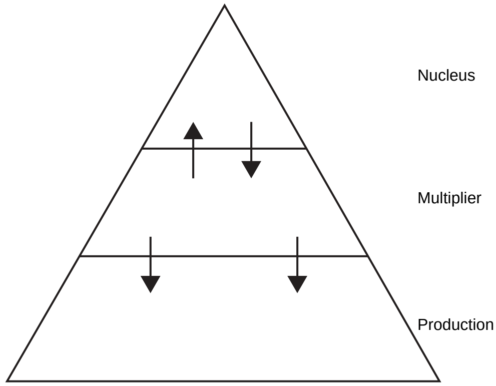

Figure 1. Breeding structure of indigenous beef cattle.

Tier 2: Multiplier

The multipliers are herds managed by progressive farmers. DLD selected a farmer group from a village near Tambon's (sub-district) technology transfer centre to set up an 'Indigenous Cattle Conservation Village' under the auspices of DLD. According to the breeding plan, the total number of farmers are 2886 in 115 villages. Each village has an average of 125 cows (one village/25 farmers, each farmer has three of their own cows, DLD sells or lends two cows). The total number of cows at the end of the project is expected to be 14,430, as shown in Table 3.

Table 3. Projected cattle population within eight years of the project.

Year	Village accumulate	Farmer accumulate	DLD sell		Farmer dam	Total
			Sire	Dam		
2001	5	125	25	250	375	625
2002	10	250	50	500	750	1250
2003	17	425	85	850	1275	2125
2004	26	650	130	1300	1950	3250
2005	39	975	195	1950	2925	4875
2006	57	1425	285	2850	4275	7125
2007	82	2050	410	4100	6150	10,250
2008	115	2875	575	5750	8625	14,375

The primary function of the multiplier is to expand the genetic material of the elite nucleus into greater numbers of animals to pass on to the production herds. Thus, the multiplier is a replicate of the

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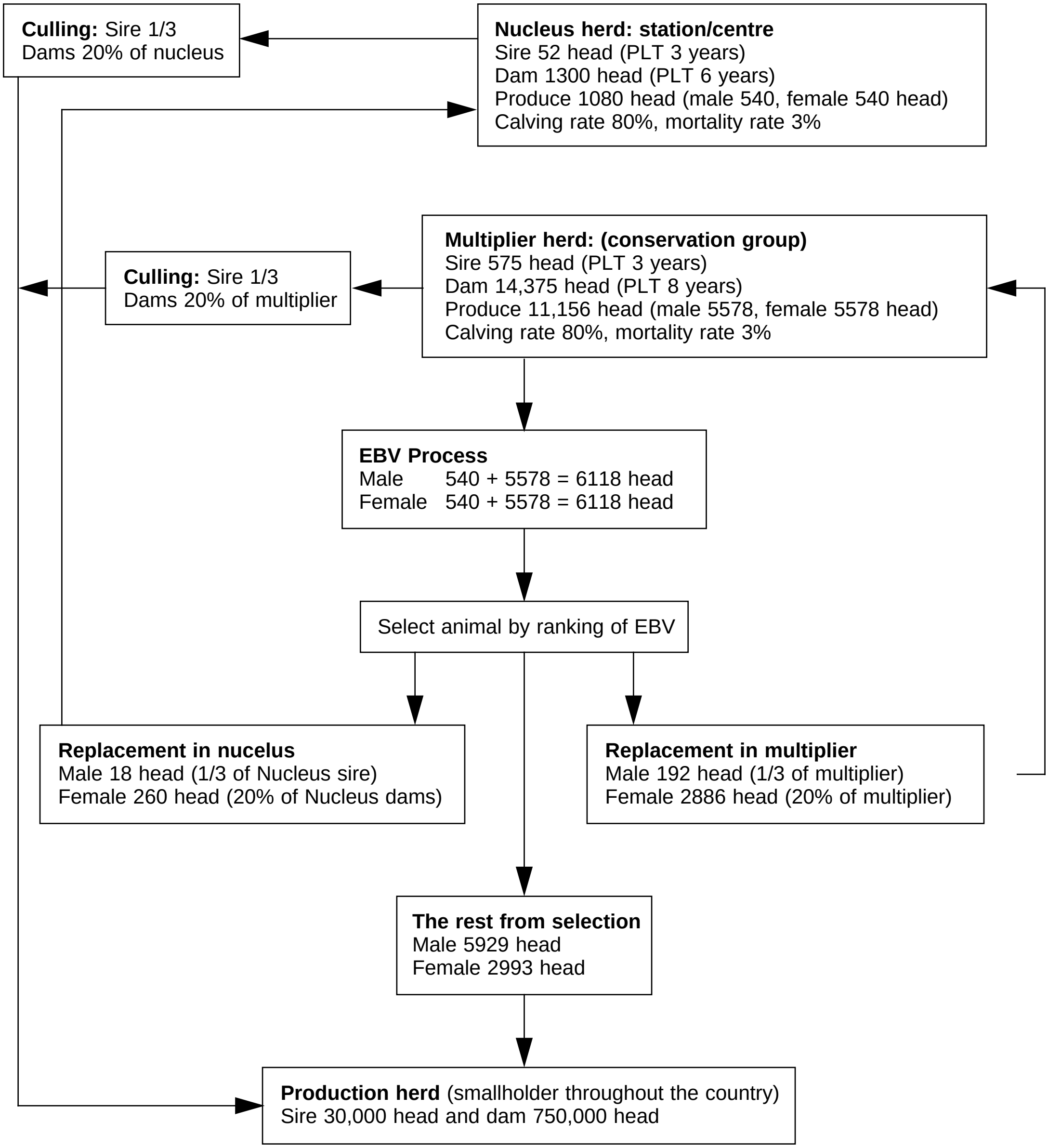

Figure 2. Action plan of Open Nucleus Breeding Scheme of Thai indigenous beef cattle (2001–2008).

original nucleus which develops into two tiers: one tier being the true nucleus while the other tier involves satellites of the nucleus.

Sire: select only from the nucleus herds.

Dam: mostly, these are the farmers' cows. Some cows may be selected from the nucleus herds. When the cows produce their offspring, pedigree and production data are collected. The data are analysed for EBVs under the BREEDPLAN program.

Male calves: high EBVs in desired traits. The DLD certifies the cattle in the database for breeding purposes and marketing information. The cattle records can be transferred to the new owner in case they are for sale.

Female calves: high EBVs in desired traits. The DLD buys back the superior animals for use as replacement heifers in the nucleus herd to produce elite sires and dams.

Tier 3: Production herd

The production herds are those raised by smallholder farmers throughout the country. They normally lack good sires. Sires from the multiplier will be sent to these herds for genetic improvement by way of support from the government through the Tambon administration organisation. Alternatively, sires can be bought from their own group.

In this breeding structure, there is evidence that the annual response to selection is increased, and that the rate of inbreeding in the nucleus is substantially reduced. James (1977) showed that for a well-designed sheep or beef cattle open nucleus breeding scheme, response to selection could be increased by 10–15%, and the rate of inbreeding could be halved, when compared with a closed nucleus scheme of the same size.

Input Required

The project will cover a period of 8 years (2001–2008). To achieve the breeding objective, the following input will be required:

1. All animals in the multiplier herds to be identified by ear tags according to the Herd Magic format and include the different village codes for the DLD database for further genetic evaluation.
2. Temporary Officers: The responsibility of these officers is to record data such as performance and pedigree, to cooperate with the village volunteer, and to provide evaluation and supervision to the village farmers.
3. Use real time ultrasonic devices for carcass measurement.

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Beef Cattle Development in Thailand

Yodchai Tongthainan[1]

Abstract

Livestock production is an integral part of Thai agriculture. In 1999, there were 4,635,741 head of beef cattle with 706,187 owners. The lowest number was 4,567,950 head in 1998 due to widespread flooding. Since then, farmers have gradually increased beef cattle production because the price has been increasing due to the shortage of supply. From 1999 until the present, the numbers of beef cattle have been gradually increasing. The major breed of beef cattle is still the indigenous breed which comprised approximately 65% percent of total beef cattle in 1999. Other breeds were purebred and crossbred which were 1% and 33% respectively. Economic traits are measured in nucleus herds. These data are recorded to personal computer using the Herd Magic program under the BREEDPLAN project, which is a bilateral project between the Australian Centre for International Agricultural Research (ACIAR) and the Thailand Department of Livestock Development (DLD). Small-scale farms are a major concern of the DLD beef cattle development program. The aim of introducing farm recording systems to the farmers is not merely for breeding objectives but for whole herd improvement. Recording is a means to that end. Other services provided by the DLD include providing cattle to small-scale farmers through the 'Cattle and Buffalo Bank under the King Initiative', free artificial insemination (AI) services and other beef cattle extension programs.

THAILAND has total land area of 513,155 km^2. Statistics from the Department of Local Administration; Ministry of the Interior, indicate that the total population of Thailand at 15 June 2001 was 62.13 million. Reports from the Department of Livestock Development (DLD) have shown that in 1999 the livestock populations of the country were 4,918,396 head of cattle, 1,799,606 head of buffalo, 7,423,101 head of swine, 118,829 head of goat, 40,900 head of sheep, 144,579,000 head of poultry, 42 million head of layer chicken, 21,000 head of duck. The farmers who raise poultry and livestock were in 3.3 million households.

Livestock production is an integral part of Thai agriculture. For small-scale farmers, crop and livestock integration is still the general practice. Diversification of farming is one of the government's sustainable agricultural development policies in order to reduce the risk of price instability of some crops. The Thai government has a strong desire to increase livestock production in order to fulfill domestic consumption demand and also for export. Most livestock promotion efforts are in the hands of the DLD. Services provided by the DLD include providing cattle to small-scale farmers through the 'Cattle and Buffalo Bank under the King Initiative', free artificial insemination (AI) services and other beef cattle extension programs.

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Beef Cattle Production

In 1999, there were 4,635,741 head of beef cattle with 706,187 owners. The number of cattle has gradually decreased since 1995 (Table 1) due to a major drop in the live cattle price. This was because of widespread flooding which occurred in 1995 and

Table 1. Number of beef cattle in Thailand.

Year	Beef Cattle (head)
1993	7,235,384
1994	7,405,732
1995	7,321,821
1996	5,854,529
1997	5,291,936
1998	4,567,950
1999	4,635,741

Source: Anon. 1999a

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1996 and many farmers changed their careers to the industrial sector or non-agricultural businesses. The lowest number of cattle was 4,567,950 head in 1998. Since then, farmers have gradually increased beef cattle production because the price has been increasing due to the shortage of the cattle supply. From 1999 until the present, the numbers of beef cattle have been gradually increasing.

The major breed of beef cattle is still the indigenous breed which comprised approximately 65% of the total in 1999. Other breeds were purebred and crossbred which were 1% and 33% respectively. Cattle fattening is a small part of beef production. The objective is to substitute for imported quality beef. The numbers are shown in Table 3.

There are very few large beef cattle farms in the country. Data from a survey conducted by the DLD in 1999 reported on the number of beef cattle and buffalo farms, by size. The data are shown in Table 2.

Table 2. Size of beef cattle farm in 1999.

Item	Range size		
Size of farm (head)	30–100	101–200	>200
Number of farms	13,459	1076	205

Source: Anon. 1999a.

Beef Cattle Development

The DLD has nine livestock research and breeding centres and 24 livestock breeding stations to conduct breeding programs, to produce breeding stocks for selling to farmers, and for supporting government projects.

In early 2001, the DLD used 3497 beef cows in the centres and stations to produce exotic breeds. There were 2314 cows used to produce purebred Brahman, 686 cows used for the 'Tak Beef Cattle Breed Establishment Project' (which aims to produce a new synthetic breed of approximately 62.5% Charolais and 37.5% Brahman), and 497 cows used for the 'Krabinburi Cattle Breed Establishment Project' (which aims to produce a new synthetic breed of 50% Simmental and 50% Brahman for dual purposes).

Table 4. Number of DLD beef cattle cows used to produce exotic breeds at the beginning of 2001.

Breed	Cow (head)
Brahman	2314
Tak Project (62.5% Charolais, 37.5% Brahman)	686
Krabinburi (50% Simmental, 50% Brahman)	497
Total	3497

Breeding Improvement

Beef cattle breed improvements are the responsibility of the Animal Husbandry Division (AHD) of the DLD. The breeding plans relate to an open nucleus herd breeding scheme. Nucleus herds are raised in some breeding centres and stations of AHD. The multipliers are some of the DLD's stations and medium-to-large private farms which are under the guidance of the DLD.

Nucleus Herd Recording

Breeding objectives of the nucleus herds of purebred Brahman, Tak beef cattle and Krabinburi breeds are to produce male calves for fattening at 450 kg final live weight or 225 kg carcass weight. The effective number of each herd is approximately 600 cows. On-farm performance testing is used to select males to be sires. Semen of the first top 10 of the tested sires are collected by the AI division to service cattle of farmers, multiplier farms and also the nucleus herds.

Economic traits measured in the nucleus herds are birth weight (BW), 200-day weaning weight (WW), 400-day weight, 600-day weight and traits of body measurement at the time of weighing. The body measurement traits are the length of hearth girth (HG), hip height (HH) and shoulder to pin bone (STP). Besides those traits, scrotum circumferences (SC) at 400-day and 600-day of the tested males are also measured.

At the centres and stations, data of the traits are recorded on personal computers using the Herd Magic program under the BREEDPLAN project, which is a bilateral project between the Australian Centre for International Agricultural Research

Table 3. Number of beef cattle of Thailand in 1999 by breed and sex.

Item	Unit	Total	Indigenous	Purebred	Crossbred	Fattening
Total	Head	4,635,741	3,014,639	48,473	1,532,871	39,758
Male	Head	1,358,469	767,672	13,755	547,284	39,758
Female	Head	3,267,272	2,246,967	34,718	985,587	—

Source: Anon 1999b

(ACIAR) and the DLD. The data are analysed to create reports for herd management at this level. The data are also sent to the AHD to compute estimated breeding values (EBVs) of those traits which are then reported back to the centres and stations. The EBVs are used to select females to be breeding heifers and cows.

Multiplier Herd Recording

Multipliers of the breeding plan are the DLD breeding stations and large-to-medium private farms. Measurements and recordings at the breeding stations are the same as that of the nucleus herds. For the private farms, the recommended measurements are the same as at the stations. However, most of the farms have no weighing scales. Therefore, only data of birth date, pedigree and body measurement traits at birth, weaning, 400-day and 600-day are able to be recorded. Data from the farms are collected by officials of the centre or station in that area and recorded in the Herd Magic program. The analysing and reporting systems are the same as for the nucleus herds.

Feedback reports to the private farms are 'Cow History Detail', 'Livestock Audit Report', 'Animal List Report', 'Full Pedigree Report' and 'Estimated Breeding Value'. Following from this, the qualifying registered breeding cattle will be certified by the DLD.

In future, if the system is fully operatational and the breeding associations, e.g. the Thai Brahman Breeding Association and the Thai Beef Cattle Association, are able to handle the system, this duty could be transferred to those associations.

Small Farm Recording

Small-scale farms are of most concern to the DLD beef cattle development program. The aim of introducing recording to the farmers is not merely for breeding objectives but for whole herd improvement. Recording is a means to that end.

Small-scale farmers are introduced to the system and encouraged by the DLD's provincial and district officials to form a beef cattle group, comprised of at least 10 farmers. Extension activities are conducted through this group. The recording system is recommended to the group in order to improve herd productivity and also to increase the farmers' incomes.

The farmers are voluntarily involved in the recording system. They must collect data related to their herds. Their cattle are tagged by plastic ear tags provided by DLD and data from the farms are collected directly by DLD officials. The farmers have no weighing scales. Therefore, only data of birth date, mating, pedigree and body measurement traits at 90-day, weaning, 400-day and 600-day are able to be recorded. The measurement at 90-day is used instead of at birth because it is not possible to measure the trait within 24 hours after birth. Data from the farms are collected by officials of the centre or station and recorded in the Herd Magic program. The analysing and reporting systems are the same as for the multipliers.

From the Herd Magic program, feedback reports to the farmers include 'Cow History Details', 'Full Pedigree Report' and 'Estimated Breeding Value'. Reports to the group register and officials involved are 'Livestock Audit Report' and 'Animal List Report' so that they will all have the information. Additional to the reports sent to the farmers are recommendations on how to use the information to improve herd productivity. For instance, cows which have a long calving interval and non-productive cows should be culled. The identification of the ear tag and the feedback reports from the AHD's officials will recognise cattle that are of a better grade than others, and therefore will return a higher selling price.

For sustainable development in the long term, the system is designed so that cattle identification, tag running number, and recording of the group members should be handled by the group staffs themselves. The AHD officials conduct only technical support and data analysis. The group is therefore asked to assign one or two of their members to operate a cattle recording register. If there is a calf born, the owner must inform the register operators who will tag the calf. Other data must be provided to the register as well. What the AHD officials do is collect the data from the group register. Feedback reports are also sent to the farmers via the register.

Apart from that, AHD can use the information to help the farmers in marketing. For instance, the AHD can provide information to national merchants and also on the DLD's internet website on cattle that the farmers want to sell, e.g. information about age and weight estimated from the hearth girth. The farmers may have to pay a fee for the cost of the ear tag, and the registering and marketing services to the group. The increased value of the registered cattle should cover the fee. It is expected that this system will continue for a considerable time because it is run on a benefit/cost rationale by the farmers themselves. Government officials help only in facilitating the system.

Conclusion

The recording system under BREEDPLAN can help government farms to improve their ability to step forward into modern beef cattle breeding and development practices. Moreover, the AHD can also apply the system to help private farms and small-scale farmers. Application of the system to the farmers is promising in its capacity to increase beef cattle productivity.

To fully utilise the system in small farms, which are the main concern of the DLD's mandate, there still are some areas that need some application and further studies. For instance, what should be the appropriate practice in the case of a farmer using bulls for natural mating while letting the herds graze together? Identification of the sire tag number of the resulting calf is impossible. Or how to design a breeding plan that can estimate reliable breeding parameters for the small-scale farmers raising only 10 to 30 cows when they use different practices from farm to farm?

Another main problem is that if the system is extended to many private farms and small-scale farmer groups, more personal computers will be needed to handle large amounts of data. For instance, 'Ban Namdib Cattle Group' in Tak province comprises 58 farmers with more than 1600 cows. Imagine the quantity of data generated. If the Tak centre had to handle 10 of these groups, it is sure that more computers will be needed eventually. This problem needs to be taken into account in forward planning for years.

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BREEDPLAN: A Further Approach to Cattle and Buffalo On-farm Trials in Thailand

Sawat Thummabood[1]

Abstract

The governments of Thailand and Australia have cooperated over several years to improve cattle and buffalo production in Thailand where livestock populations had decreased in recent years to a level below national consumption demand. Using the Australian-developed BREEDPLAN, farmers across Thailand have the opportunity not only to increase livestock production levels, but also to improve the genetic value of the country's breeding stock. This paper provided details of the plan and its propagation through on-farm trials conducted under the auspices of the Department of Livestock Development of the Government of Thailand.

LIVESTOCK production is very important to the agricultural development of Thailand because Thailand is a tropical country that can produce animal feed all year round, especially forage crops and weeds.

Cattle, buffalo and other ruminant animals convert these feed crops to animal protein for human consumption. Cattle and buffalo production therefore contributes in a very important way to the economy of Thailand, and distributes income among small-scale farmers and villagers.

Cattle and buffalo are mainly raised by small-scale farmers who are the major portion (65%) of the total population. Buffalo and native cattle have been part of Thai agriculture for many centuries. These animals have been the subject of natural selection for breeding, disease resistance and survival under natural conditions on natural forage. They have adapted so that they can work and survive in a harsh environment.

Cattle and buffalo breeding improvement by the Department of Livestock Development (DLD) has been subjected to close herd breeding programs which are conducted in 40 livestock breeding stations located in various parts of the country.

The breeding program does not take into account farmer participation; rather breeding and selection are conducted under governmental auspices. The propagation of genetically improved breeding stock has been conducted by the Livestock Extension Division of DLD by providing proven sires to groups of farmers to help improve their farm animals, and by artificial insemination (AI) methods.

However, the results of cattle and buffalo production promotion proved unsuccessful and populations declined significantly due to the high price of agricultural land, combined with low prices for agricultural products. This situation caused many farmers to sell their breeding stock and migrate to work in cities, leaving aging and older people to conduct agriculture and livestock-raising.

Cattle numbers declined from 7.61 million in 1995 to 4.91 million in 1999, while buffalo declined from 3.7 million in 1995 to 1.3 million in 2001. The present situation is becoming even worse because there is a high consumer demand for buffalo and beef products. The Government and the DLD are focussing on encouraging small-scale farmers to return to cattle and buffalo raising as part of the farming system and is using BREEDPLAN as a tool for the project, based on on-farm trials to ensure farmer participation.

In 1995, the Australian Centre for International Agricultural Research (ACIAR) funded a project (PN9311) for DLD to establish a database system for genetic evaluation and improvement of beef cattle and buffalo in Thailand. The computerised data were then analysed using GROUP BREEDPLAN, a pedigree and performance recording system developed in Australia. The estimated breeding values (EBVs) for individual animals are obtained using a multi-trait

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animal model in a Best Linear Unbiased Production (BLUP) method for across-herd evaluation. The influence of management, environmental effects and non-genetic effects are taken in account. The aim of the ACIAR project was the genetic improvement of Thai beef cattle and buffalo herds through the use of a government breeding program using BREEDPLAN EBVs to select superior breeding animals. The DLD then used various extension programs to take these superior animals into village production systems.

The adaptation of Herd Magic software for on-farm data capture for use by the DLD stations was very successful. It provides a local benefit to the station as a farm management tool as well as improving the quality of the information being stored. It also acts as a standard interface to the central computer located at the DLD office in Bangkok.

Using BREEDPLAN to evaluate the data from the DLD stations spread across Thailand has enabled the DLD to select the better performing animals without the need for a central performance testing station. This has meant a saving to the DLD of 4–5 million Baht per year.

The system is now being expanded by DLD to include data on livestock recording in the villages of the on-farm trial project. This will assist government farms in producing good genetic parent stock that performs well under village conditions. As well as improving the genetic potential of the livestock, the scheme will also be used to train villagers in breeding improvement and explain EBVs as one of its tools. Hence, it is expected that EBVs will become more widely understood and be used in the trading of breeding animals. The use of villagers in the recording program will also lead to in situ genetic conservation of the native cattle where low input combined with sustainable production systems will help meet local beef consumption demands.

The on-farm trial has been designed for disseminating superior and improved genetic stock in the nucleus breeding herds to the multiplier population at the village level; then the multiplier population will produce good, adapted breeders to the base or commercial population. Some portion of superior high EBV cows will be purchased from the multiplier population, adding genetic variation to the nucleus herd. This technique has been well known as the 'open nucleus breeding scheme'. During the year 2000–2001, the DLD plan to set up 800 on-farm trial sites involving 20,000 farmers and 100,000 breeding cows of both cattle and buffalo with the expectation of producing good genetic parents to the base population of 4.9 million cattle and 1.3 million buffalo. Starting from the year 2000, we have already implemented 50 on-farm trial sites in four regions of the country. We have already released 400 buffalo bulls and cows and 600 native and crossbred cattle bulls and cows from the nucleus herd.

The on-farm trial program is strongly supported by the government and DLD policy in which DLD provide 16 million Baht finance for the first year, followed by the government allocation of 500 million Baht in the fiscal year 2002 budget to the Tumbon and village organisation for producing livestock targeted to increased cattle and buffalo production. However, the DLD provides at least 200 million Baht in its annual budget for research and development of beef cattle and buffalo production.

The four steps of the on-farm trial are:

1. Selection of farm sites based on purposive sampling. The villages selected should be those having buffalo and cattle raising activities and are selected as the DLD contact villages. They should have a Tumbon training and technology transfer centre under the administration of a Tumbon committee and local organisation. The DLD provide them with technicians. Two villages are selected from each Tumbon.
2. Each village selects 20–50 farmers to participate in the on-farm trial, selected by way of questionnaire and interview results. The selected farmers are registered as DLD contact farmers who obtain buffalo and cattle cows and bulls separately from the DLD animal breeding improvement stations. Each village is provided with one bull and 50 cows. These breeding animals are pedigreed with performances recorded, e.g. weaning weight, 200 and 400-day weaning weight, body measurement, days to calving and adapted traits.
3. The breed multiplication process is designed to allow the contact farmers to produce register breeds for sale to the other general farmers. The DLD will certify their breed status, based on EBVs and pedigree records.
4. The recording system is based on pedigree records. All of the animals are tattooed with a given specific number as an individual identification. The biological information will be recorded by the 200 DLD technicians that are working in the livestock breeding improvement stations in four regions of Thailand.

Design of Breeding Programs

Hans Graser[1]

Abstract

Breeding programs are businesses whose aims are to make genetic gain and produce a positive return on investment. Good designs can maximise those returns within the limited funds available for investment. This paper describes some aspects of the computer program ZPLAN, which performs design calculations based on the gene-flow method and selection index principles. A large number of population parameters are required for such an exercise. These are commonly not available at the start and need estimation after the breeding program has been running for some time. The DLD breeding program for Thai Native Cattle is used as an example.

GENETIC improvement programs for livestock are businesses and should therefore be designed to maximise an objective which could be e.g. the return on investment or maximum genetic gain. One should aim for such an objective regardless of whether the improvement program is managed at a state/ government level, by a private company or for an individual herd. With finite money/resources invested in the improvement programs, different breeding activities compete with each other and we have to find a combination and level of activities which maximise the objective. The following outlines the strategy we used to evaluate different options for an economic design for the Thai Native Cattle breeding program within constraints given by the Department of Livestock Development (DLD) of the Thailand Government.

The Task

The DLD made the decision to plan and implement a genetic improvement program for Thai Native Cattle. There were a number of reasons for the DLD to get involved in such a breeding program:

- improving the economic situation of small Thai beef cattle producers;
- securing a base supply of beef to Thai people from within Thailand;
- utilising the adapted genotypes of Thai cattle;
- conserving biodiversity in Thai Beef cattle.

There was an understanding that the current structures within the Thai Native Cattle population require some direct involvement of DLD livestock centres to maintain and improve a nucleus of these cattle whose progress will be disseminated via a multiplier tier to the small commercial village farmers. We have been asked to assist in the planning of and optimisation of such a breeding program. As with all governments, money is limited.

The Method

To evaluate different designs, we used the program 'ZPLAN' developed by Karras et al. (1997) at the University of Hohenheim, Germany. This program calculates the returns and predicted genetic gains from one round of selection in a deterministic way. To achieve this, the program uses the classic gene-flow method by Hill (1974) to calculate discounted economic expressions and selection index theory to calculate genetic gain for a defined breeding objective and an evolving performance recording system.

To use Hill's gene-flow method, the very first requirement is to identify the parent groups which contribute genes to the next generation. Figure 1 identifies those groups in the classical way of sire of sires etc in the three tiers of the breeding pyramid: nucleus, multiplier and commercial.

In the Thai Native Cattle breeding program, we have identified in the first instance 10 different

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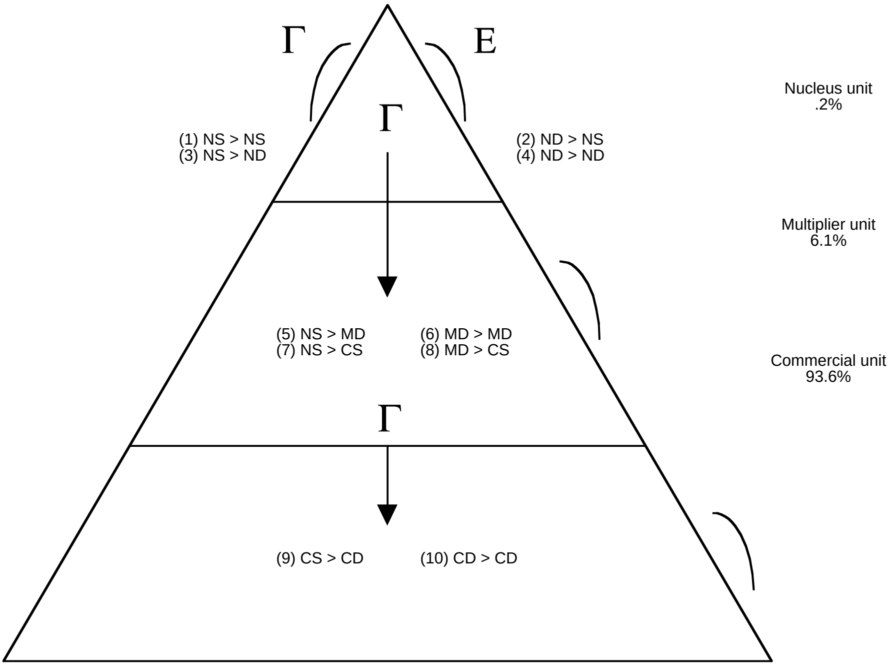

Figure 1. Breeding structure and selection groups of the example Thai Native Cattle population. NS, ND; sire and dam in the nucleus unit; MS, MD; sire and dam in the multiplier unit and CS, CD; sire and dam in the commercial unit. Code for selection groups correspond to their order in the transmission matrix.

parent groups contributing genes to different progeny groups in the three tiers. The next step in developing the gene-flow is the description of all these parent groups with respect to:

- age at birth of first progeny;
- regular calving intervals;
- average number of years the parents are used; and
- average survival rate from one age-class to the next.

With this information, we can calculate an age distribution of the female herds and the sires and develop the transmission matrix **T,** which is the key descriptive element of Hill's gene-flow method, Figure 2. Each parent group has to be produced either from its own (self replacing) and a mating partner group of the opposite sex (e.g. NS and ND), or in the case of commercial sires CS, which are not self replacing, by two different parent groups. Animals do age and move from one age class to the next, which in beef cattle is conveniently one year. The diagonal of ones reflects this. The × symbolises the proportion of genes contributed to the next generation by each sex age class. These × sum up to 1 across all parent groups in each reproduction row.

By multiplying this matrix with a serious of vectors l_n, which originate from the product of the matrix and an initial vector l_0, which indicates the group with improved genes, one can calculate for any one year the % of genes originating from any of the specified parent groups in the population over time:

$$l_n = l_{(n-1)}\mathbf{T}$$

For example, selecting yearling bulls in the nucleus, it will take a number of years for those 'improved genes' to appear in one year old animals (breeding or slaughter) in the commercial herd. After many years, every animal in the commercial sector will have an equal % of improved genes from that one round of selection. For more details, see Hill (1974).

Calculating Genetic Superiority of Selected Animals

To calculate genetic superiority ΔG of the selected animals the program uses the standard formula

$$\Delta G = \sigma_a * \mathbf{acc} * \mathbf{i}$$

with

- σ_a = genetic standard deviation of the breeding objective
- **acc** = Accuracy of selection (correlation between true and estimated breeding value)
- **i** = selection intensity

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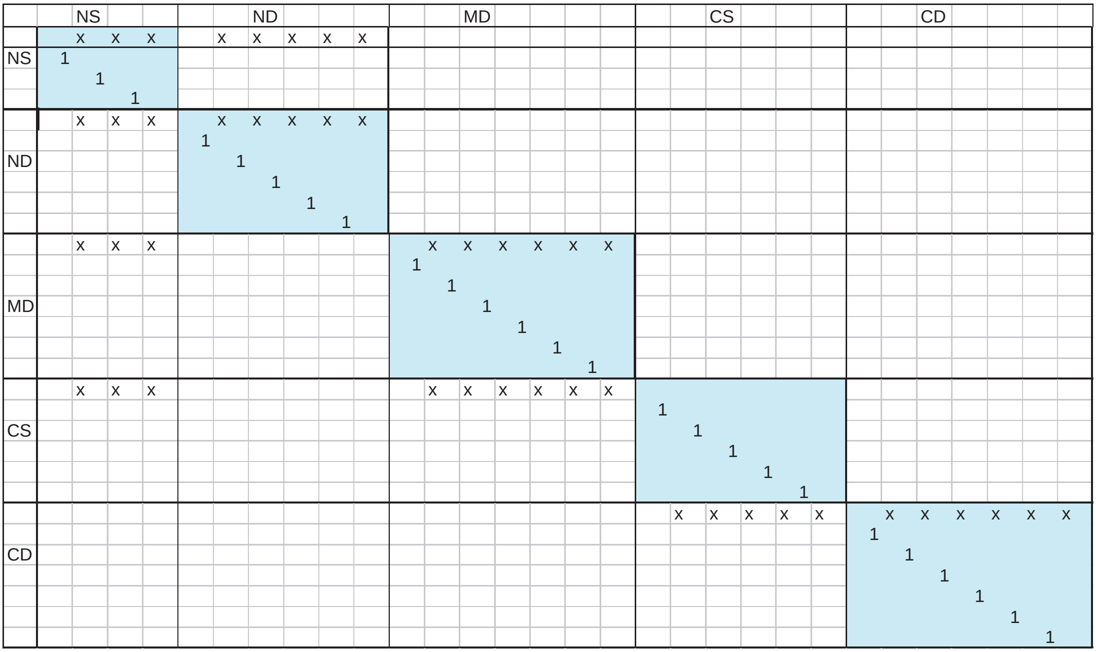

Figure 2. Example of the structure of a gene-flow transmission matrix **T**.

The most difficult part in the planning of a breeding program for Thai Native Cattle was the definition of a breeding objective which accounts for all economically important characteristics of animals in a village production system. Through natural and human selection Thai Native Cattle are well adapted to their environment and highly fertile. Of course, this adaptation and fertility has to be maintained or only reduced slightly while the production characteristics, growth and carcass qualities are improved.

How do we define adaptation other than as reproduction by the fittest? We have to identify selection criteria which are correlated to adaptation and can be objectively measured early in life under the management of the more benign environment of a nucleus herd.

For the Thai Native Cattle we have defined a first objective as follows:

- increase sale weight of slaughter animals and cull cows;
- increase carcass meat yield;
- maintain or increase cow weaning rate;
- maintain adaptation recorded as survival;
- improving temperament to make handling easier.

Table 1 provides the combined wisdom of the steering committee, which developed from this overall objective a breeding objective and also made some educated guesses about the genetic parameters and economic weights.

Table 1. Traits in the first breeding objective for Thai Native Cattle with relative economic value and assumed genetic standard deviation and heritability.

Trait	Ec. value Baht	h^2	σ_a	$v * \sigma_a$
Sale weight direct, kg	20	0.25	11	220
Cow weight, kg	10	0.20	9.8	98
Cow weaning rate, %	50	0.05	8.9	447
Adaptation, score	3000	0.20	0.45	1350
Temperament, score	–1500	0.20	0.45	675
Meat yield, %	200	0.40	1.3	260
Sale weight maternal, kg	20	0.10	7.0	140

Adaptation and temperament are scores with an underlying phenotypic standard deviation of one.

Identifying Possible Selection Criteria

Having defined the breeding objective, the next step was to look for possible selection criteria, traits, which could be objectively measured in one or all of the tiers and which are correlated with one or more of the traits in the breeding objective. Some selection criteria could be traits from the breeding objective. However, it is not enough to identify possible selection criteria; we also have to calculate the real cost of recording and adding the trait to the data and genetic

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evaluation system. Table 2 presents the selection criteria, which we identified in this first stage of our investigation for the Thai Native Cattle breeding program.

Table 2. Possible selection criteria for the Thai Native Cattle breeding program.

Name of trait	h^2	σ_p	Recording cost (Baht)
Weaning weight	0.20	16	4
Yearling weight	0.25	18	4
Cow weight	0.20	22	4
Heart girth	0.10	8	3
Hip height	0.20	6	3
Body length	0.40	8	3
Scrotal size	0.30	1.8	5
Day to calving	0.07	23	10
Age at 1 calving	0.10	0.39	0
Tick count	0.42	0.59	48
Temperature	0.17	0.08	10
Faecal egg count	0.35	0.58	48
P8 fat (scan)	0.30	1.5	160
Eye muscle area (scan)	0.25	6.0	

As we have very little knowledge of the genetic parameters for many of the traits for these animals, we had to rely on our Australian data from tropically-adapted breeds and make some informed guesses and adjustment to the smaller body size. The same has to be said for all the genetic and environmental correlations, which are required for the calculation of the Index, or better the Breeding Value for the Objective.

In our choice of possible selection criteria, we tried to address all five groups of economically important characteristics: growth, reproduction, temperament, adaptation and carcass quality. We identified three selection criteria which can be objectively measured and we believe are correlated to adaptation (survival) in the Thai village environment. These were tick count, rectal temperature and faecal egg count. All these traits can be recorded under the more intensive management system of the nucleus herds.

We also considered that some of the traits might only be recorded in the multiplier tier (body size measurements). We asked the question: 'Is recording justified in the multiplier tier to increase the selection accuracy of sires being used at the village level. As no genes from the multiplier unit flow back to the nucleus, this recording has no effect on genetic progress.

With the breeding objective and selection criteria identified, we can use selection index theory to calculate the accuracy of selection for each of the 10 parent groups in our breeding pyramid. Of course, these accuracies will vary with the number of animals and particular progeny, as well as the actual traits recorded. We can evaluate which traits are cost effective to record and if funds are really limited answer questions like: 'Is it more economical to record growth or scan the animals for carcass quality?'

We believe we have made a good start in the definition of a breeding objective and correlated selection criteria. Of course, it is not perfect and requires much more research on data collected in the future and perhaps new ideas.

Breeding Structure and Number of Animals in Different Tiers

To calculate the selection intensities, we have to know the number of animals performance tested for each of the 10 groups and the number of animals required as replacements. To do this, a large number of additional biological parameters from our cattle population are required. We have already identified the age structure in the different tiers to establish the gene transformation matrix **T**. We need the actual number of animals, calving rate, survival to different stages prior to joining the parent population, mating ratios for natural mating and possible AI and the planned size of each of the three tiers to calculate the selection intensity from the number of animals tested and the number of animals required as replacements. An important variable is also the proportion of animals that cannot be used for breeding for reasons other than genetic, e.g. failed health test, semen cannot be frozen, etc. If we do not consider these 'losses' we will overestimate the selection intensity and subsequently the returns and might favour a sub-optimal design.

The size of the total population was given by the estimate of the Thai Native Cattle population of 800,000 cows. The size of the nucleus was first set as a guideline by the DLD and restricted to 1000 cows. The multiplier tier had to be big enough to service the commercial village herds so that all bulls used for breeding where bred and recorded in the multiplier tier. Figure 1 includes the proportion of cows we have to have in the nucleus and multiplier tier to service the breeding program. It is the task of our design calculation to optimise the proportions in any of the three schemes.

With the biological parameters implied at the nucleus, multiplier and commercial tier, it became immediately obvious that the initial size of 1000 cows in the nucleus was insufficient to provide enough replacement bulls for the multiplier unit. We had to increase the nucleus to approximately 1200 cows.

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Costs of a Breeding Program

As already mentioned previously, breeding programs are costing money. We distinguish fixed costs for the program, fixed costs per cow and variable costs depending on the recording system or breeding system used.

Fixed costs are basic management costs for the breeding program which are in addition to the pure production costs and commonly independent of the size of the breeding program. It is not always clear if costs are only breeding related or are general production costs. For example, ear tags for cows and calves can be seen in Thailand as required for breeding only, whereas in Australia they are becoming a requirement for production to track animals from abattoir back to herd of birth.

Variable recording costs have already been outlined in Table 2. Other costs that we have to consider are, for example, transport costs for bulls from the nucleus to multipliers and from multipliers to the villages and the possible cost of AI, production and storage cost of semen and as a negative cost, if we can save the money by using AI, the maintenance costs of bulls.

Investment Parameters

Finally, as costs and returns do not occur at the same time, we have to use interest rates to calculate the returns and costs in present values. As genetic changes are permanent, but flow through the population is slow, we have to use a realistic time horizon over which benefits are allowed to accumulate.

Output

Having defined all those variables in a parameter file, the program calculates the returns and costs and genetic gain for the objective and individual traits for the base situation. Certain variable can then be varied and the program will recalculate the results for every level and if desired select the combination with highest gain or profit for printing. Otherwise, the results for every variable combination is presented in a number of Tables but unfortunately not yet in graphical form.

Many of the variables used have dependencies and constant recalculation of variables by the program is required. For example, if we increase the number of sires used in the fixed size nucleus, we change the number of halfsibs and progeny of any one animal. This reduces the accuracy of the calculated EBVs and also decreases the selection intensity, while the increase in inbreeding is reduced.

There is also the question of optimal use of sires in the multiplier herds. As we reduce the years of use, we reduce the time lag between nucleus and commercial cows while decreasing the selection intensity for sires going from the nucleus to the multiplier tier and increase transport costs.

Conclusions

To investigate possible designs for the breeding and performance recording program for Thai Native Cattle, ZPLAN has proven quite useful. It required a clear definition of a breeding objective and the specification of many technical and biological parameters. Many of these parameters can currently only be guessed and careful monitoring in the next years will prove their value. In particular, genetic parameters are poorly understood and only new data and estimation in coming years will produce improved information. At that time, it will be necessary to evaluate the design again and if necessary make changes.

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Sustainable Management of Beef Cattle and Buffalo Genetic Resources in Asia

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Abstract

The demand for livestock products is set to continue rising at a high rate for the next 20–30 years. Genetic evaluation both between breed and within breed has an important role to play in the livestock revolution and has certain advantages but cannot be considered in isolation. The maintenance of genetic diversity is crucial for long-term sustainability and both in vivo and in vitro schemes should be considered as elements of the same policy. The use of all available resources in a manner which does not result in the reduction of and/or damage to resources for future generations is perhaps the most important consideration now required of all countries.

THE EVENTS in world agriculture in the next 20 years predicted by the International Food Policy Research Institute (IFPRI) in the study 'Livestock 2020 the Next Food Revolution' (Delgado et al. 1999b) have been referred to as the 'Livestock Revolution'.

The dramatically expanding demand for livestock goods is the result of a combination of high real income growth, population growth, urbanisation and the diversification of the diets in developing countries away from very high levels of starchy staples. Milk consumption has grown more than 3% per year and is projected to grow even faster until 2020. Meat consumption has been growing about 5% per annum and is expected to grow 1.8% per year until 2020. The predicted growth is summarised in Figures 1 and 2.

Country aggregates are defined as follows:

Southeast Asia: Brunei, Cambodia, East Timor, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam.

Other East Asia: Hong Kong, Macao, Mongolia, North Korea and South Korea.

Other South Asia: Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka.

Delgado et al (1999a) predicted that all subregions within Asia will have relatively high levels of increased total consumption—the lowest being for milk/milk products in North and South Korea, Mongolia, Hong Kong and Macau (i.e. East Asia, Table 1.)

Conservation equates with the sustainable management of (beef) cattle and buffalo. This is perhaps a way not only to meet the challenges of the future demand for livestock products but also to conserve genetic diversity while following the general principles and parameters of sustainable management of any breed.

Asia appears to have taken some understandable short-term measures without also taking long-term actions which would have given support to the immediate desire to feed people. This difficulty is part of the problem of most assistance being in the form of short term programs (at least in the time scale required for genetic changes to occur and be quantified).

It is necessary for each country to undertake a series of actions to develop an optimal strategy to respond to the 'Livestock Revolution'. This potential market was not quantified until fairly recently and places new and even greater demands on each country at a time when environmental pressures are growing both factually and in the public awareness.

The following aspects should be studied and conclusions reached:

- Analysis of the present systems and establishment of development objective for each production system for the next 20–30 years;
- Evaluation of market changes and future demand;

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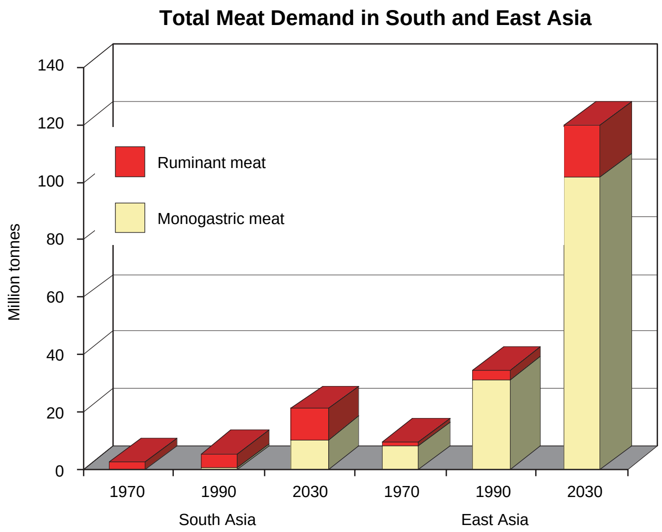

Figure 1. Predicted growth in meat consumption up to 2030.
Source: Steinfeld H. (pers. comm.).

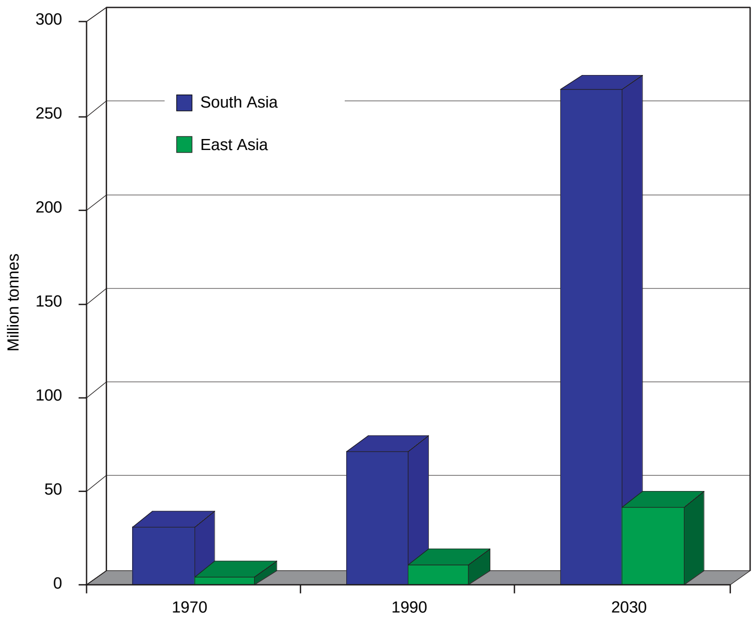

Figure 2. Predicted meat consumption in South Asia and East Asia to 2030.
Source: Steinfeld H. (pers. comm.).

Table 1. Baseline projections of Asian food consumption and trade for meat and milk, 2020.

Region	Projected annual growth of total consumption 1993–2020		Total consumption in 2020		Net exports in 2020		Per capita consumption in 2020	
	Meat	Milk	Meat	Milk	Meat	Milk	Meat	Milk
	(percent per year)		(million MT)		(million MT)		(kg)	
China	3.0	2.8	85	17	0.7	0.5	60	12
India	2.9	4.3	8	160	0.0	0.1	6	125
Southeast Asia	3.0	2.7	16	11	0.5	–7.8	24	16
East Asia	2.4	1.7	8	2	–1.3	–0.4	67	20
South Asia	3.2	3.4	5	41	–0.6	–2.8	10	82

Source: Delgado et al. 1999.
Notes: Consumption is direct use as food, uncooked weight bone-in. Meat includes beef, pork, mutton, goat and poultry. Milk is milk and milk products in liquid milk equivalents.

- Activities to increase market value and competitiveness;
- Establishing the true economic performance of the breed (no externalities);
- Improvement of infrastructure and technical assistance;
- Genetic strategy and improvement;
- Optimisation of the production systems;
- Policy decisions regarding long term industry structure.

Such studies are required urgently so that full planning for the whole of integrated agriculture can form the base for taking advantage of the opportunities offered by the potential demands for animal products. Some initial activities have been and are continuing to be undertaken by the Food and Agriculture Organisation (FAO) and other agencies through the Area Wide Integration (AWI) and Livestock, Environment and Development (LEAD) initiatives. As far as possible Asia should take advantage of these and other possibilities for policy reconsideration. In addition, the forthcoming State of the World survey on Animal Genetic Resources to be undertaken by FAO is likely to raise many of the questions identified in greater detail than mentioned in this paper since genetics cannot be considered in isolation from all other factors.

Analysis of Present Systems and Establishment of Development Objective

All present systems need to be analysed for their use of local and 'imported' resources, efficiency of production, suitability for future conditions (production environment and market), the social implications of the system and the effect on resource availability and environment.

Under which conditions can developing countries afford to concentrate on single purpose breeds such as highly selected and specialised beef or dairy breeds which require qualified management and increased feed and health care? The corollary is to ask 'for long-term sustainable production, is the overall agriculture, economic and social environment more favourable to improve the local breeds either as pure breed or crossbred, or to use single or dual/ multiple purpose breeds?'

The economic aspects should be considered separately so that externalities can be identified and quantified (or their effects studied). The development objective will need inputs from other sectors before it can be fully identified.

Evaluation of Market Changes and Future Demands

The effects of recent changes in the market on the system and its components need quantifying. The future changes in the type of demand for products (eating habits) and in the marketing systems will need careful consideration so that the implications can be reasonably predicted in terms of affects on the various aspects of the production systems and the potential social implications. This will also require study of the potential to *improve competitiveness by increasing market value.*

Establish the True Value of the Breed/Crossbreed

Trials need to carefully study the biological criteria within the system and in any system likely to be adopted within the time horizon. The evaluation should attempt to include other breeds considered to be of real potential since there is little data available

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elsewhere which can assist. The breed evaluation data available is referred to in a later, more detailed section on 'genetic strategy and improvement'. The trend to use non-locally developed and adapted single purpose breeds has started to reduce indigenous populations and may decrease the number of local breeds and threaten their existence. This does not mean that schemes should not be sensitive to the needs of the growing human population or to the changes in agriculture and livestock sector. It means that a well considered decision will have to be made as to which breed or breed combination is the most appropriate for a given environmental context, market and consumer demand. The need to maintain animal genetic diversity has generally been accepted in principle but there is still considerable potential for serious losses of farm animal resources.

Improvement of Infrastructure and Technical Assistance

The implications of changes in infrastructure need to be estimated both in terms of effects on systems, markets and social consequences. Similarly, the provision of expert technical assistance, its cost effectiveness and social implications of different options have to be studied. The level of research required in order to provide information also should be assessed and evaluated. The long-term (sustainable) levels of improvement in technical aspects and infrastructure have to be evaluated so that costs are not externalised in predictions of future systems and the likely economic outcomes. The role and methods of implementation of extension services and long-term potential structures need careful consideration. This section might also consider the potential role of new technologies but avoid over optimistic assumptions. Semen sexing was 'just round the corner' for some fifty years!

Genetic Strategy and Improvement

Diversity

Genetic change within a species depends on genetic differences either between breed or within breed. The key is total genetic diversity with the breeding strategy aiming to harness those differences in ways that depend upon the type of variation involved. It is important that breeds are evaluated to identify their contribution to diversity and also if they have any specific traits either of importance or which are not common to many other breeds—for example, specific disease tolerance/resistance or physiological advantages which enable them to resist extreme temperature, etc. These traits can be of value in the normal environment but also, given developments in genetic engineering, may be transferable to other breeds in due course rather more directly and accurately than existing breeding practices allow. Indeed, after decades of neglect, local breeds are now considered as a source of useful variation (Frankham 1994). The maintenance of diversity is also valuable in that heterosis can continue to be fully exploited for its beneficial contributions to animal production (remembering that not all heterosis is beneficial).

The major concern is that of maintaining genetic diversity and the maintenance of all breeds is not a realistic long-term strategy. However, relatively little is known about genetic diversity of cattle and buffalo at present but, in time, it should be possible to develop a strategy to maintain diversity without keeping the majority of breeds.

There is urgent need for this type of information and International Livestock Research Institute's (ILRI) efforts in this area are acknowledged. Further efforts to characterise breeds using DNA is crucial to the best use of genetic resources globally. Studying the literature of the work which is undertaken by many universities and research institutes and taking into consideration the cost involved, a better world-wide co-ordination of these activities would be beneficial. The use of the International Society for Animal Genetics (ISAG) recommended minimum primers, the sample sizes and sampling methodology provided by FAO (FAO1998) would be a major move in this direction.

Breed use and evaluation

The region has many examples of introduction of exotic breeds, normally through AI, with the subsequent success of the F1 being followed by varying results either in the 75% exotic or further backcrosses to the exotic (misleadingly termed 'grading up' by many). These have occurred in both beef and dairy sectors but the records are mostly available for dairy production. The results of crossing programs have, therefore, been brought into question especially as the optimal level of exotic input is often difficult to maintain in practice. An example from the dairy sector: in the Medak district in India, Yedukondalu (2000) reports that in the span of six years there was a reduction of 14% of total cattle and an increase of 10% in the buffalo population, indicating a clear preference to buffalo over cows. The trend gave also a clear indication that the dairy farmers were preferring the indigenous type over the crossbred cows and this might be due to the problem of managing crossbred cows with particular reference to their health management.

There are no major research results involving Asian breeds which adequately try to evaluate breeds and the type of genetic variation—indeed globally there are very few such experiments for any breeds. There are even fewer breed comparisons which use more than a single environment—examples of some which do are the United States Department of Agriculture (USDA) Meat Animal Research Centre, Meat and Livestock Commission and Animal Breeding and Research Organisation in UK and the Cooperative Research Centre for Meat Quality, University of New England, Armidale, NSW Australia (CRC) results in Australia. Most of these trials indicate that the proportion of within breed and between breed variation varies for different traits—in growth most is between breed whereas for feed efficiency the indication is that within breed variation is the more important. Hammond and Leitch (1995) conclude that overall the apportionment is about equal for between and within breed variation.

For some traits, where there is very little additive genetic variation, breed differences are nevertheless genetic even though further genetic change is slow and unlikely. In such cases, the selection of the right breed is absolutely crucial to the exploitation of the trait concerned. As suggested earlier, crossing produces an F1 which, in most circumstances, will outperform the local breed in the context of the required product output. This can be impressive but does nothing to indicate the real value of either breed to the whole system. The successful F1 is usually followed by (erroneously termed) 'upgrading' to the exotic, creating often even more problems . Genetic erosion can occur quite easily and the effects are not necessarily easily seen in the crucial early stages.

Asia has, for the past 20–30 years, been the receptacle for more 'exotic' genes than almost anywhere else in the world with nearly every country aiming to increase food output as quickly as possible. Asia has crosses with many 'exotic' breeds in almost all environments but, in general, has no comprehensive information on their performance. However, recently, there has been the realisation that a certain proportion of local genes appears to be crucial for optimal production. This is most obvious in the dairy industry where one major breed has been used (Holstein-Friesian). Such experience and the problems encountered in attempting to identify the optimum have caused many to review the old policy best described as the 'worship of the exotic'. Experience has shown that reliance on 'exotics' is not advisable where stress is still a regular part of the production environment. Many countries within South East Asia have begun to re-assess the relevance of their genetic resources in livestock and policies are being reviewed albeit mostly without full information.

Before breeding schemes can be effectively designed, it is necessary to know what genetic material is available, what production systems are to be used and what are the overall objectives. Production systems need to exploit the genetic material to maximise sustainable efficiency of the whole rather than any specific subsection of the system. Without detailed breed evaluation, it is extremely difficult to plan to optimise but this is more often the case than not.

Breed purpose

The ruminant is essentially a walking biodigester which produces material of value to humans. The efficiency of the biodigester has to be assessed both in terms of outputs and of inputs although, to date, the majority of countries appear to consider output of more importance. This may well have a biological basis but it may not. For example, the partition into separate breeds to provide milk and beef in the 'developed world' is more a result either of system demands (e.g. USA beef ranches well away from populous areas) or of policy directed by subsidy (e.g. most of Europe). This is not to say that they are incorrect but the reasons may not be either relevant or applicable to Asia. For example, prior to the major political interference in Europe, most systems used dual-purpose cattle breeds (including the Friesian) which were later displaced in many areas as subsidies were used to direct and dictate farmers' actions. At present, there is a move in parts of China to change the local Swamp type buffalo into a dual purpose type by crossing with Riverine type—a policy adopted in the Philippines almost 20 years ago. The full consequences are still being evaluated in both countries but could provide valuable indications for others.

National considerations of the biological efficiency of different options and the social consequences are ways in which Asia can attain advantage over some of the developed country production systems. Perhaps Australia is the one country which has now done sufficient research to enable farm system, environment and market to be optimised with the use of specific breed inputs (but not Asian breeds). The CRC data could be of value in the context of Asian planning, since it covered environments similar to those found in Asia.

Breed Management Options

The management of farm animal genetic resources is, in principle, no different to the proper management of any resource—to ensure that it is looked after properly and used to advantage in a sustainable

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manner. There are however, different options as to how a resource may be used. Since, in many cases, numbers have already been reduced, there may be some difficulties in operating a fully fledged breeding scheme although this will depend on the objectives as well. For example, dual-purpose and/or dairy improvement is more demanding in terms of population size than is beef improvement. The background to obtaining information and the options open in the context of 'conservation' (used in its fullest meaning, i.e. best management) are well discussed in the FAO publication 'Secondary Guidelines for Development of National Farm Animal Genetic Resources Management Plans—Management of Small Populations at Risk' (FAO 1998).

These options will be discussed in this paper and, where possible, examples from within the region mentioned. The primary option is to try to secure the profitability of the local breed when full and proper costing is undertaken (this means the inclusion of 'externalised' costs, subsidies, lifetime productivity etc). While the answers may not be 'economic' in the sense of an immediate, political answer, they do provide a more long term, sustainable view than the immediate 'politically correct' but insecure answer. There is good evidence that subsidies to support the introduction of 'exotics' are common. Economic criteria need considering in the context that politicians can and do change them at the proverbial 'drop of a hat'.

The reasons for the lack of immediate profitability should be identified and potential solutions developed. If breeds that can reproduce well and regularly under the relevant conditions are being used, then solutions could well be to do with output—most traits of which can be improved by selection within the breed or by producing crossbred progeny with breeds of high merit for the required traits. For example, Laos is attempting to select good local bulls to improve its beef breed in the north while Thailand is selecting its buffalo for faster growth. In addition, Thailand now has herds of both Thai native and Kao Lamphun cattle with a view to pure bred selection—whether solely for pure bred production or for producing crossbred calves for feeding to slaughter is not fully clear at this moment. This development appears to be going on independently of the dairy industry which is based on crosses—usually between either local or Brahman and the Holstein Friesian. Other countries operating small nuclei of local breeds are Philippinnes, Indonesia with Madura, Bali and Ongole Malaysia with Kedal Kelantan and many breeds in India. The decision on whether a pure breeding scheme for improvement is feasible will be dependent upon the size of the population—an 'Effective Number' (Ne) of at least 50 is sensible before embarking on such a program (see FAO 1998 for various references). Even then, the cost effectiveness has to be studied carefully beforehand.

On some occasions, the local breed can be fitted into a crossbreeding scheme to improve efficiency, output and profitability. In Malaysia, the Kedah Kelantan as well as having a small purebreeding unit, is used in a rotational crossing programme that requires the maintenance of all three breeds. This scheme actually includes another element which is marketing a specific, identifiable product (as a niche market).

Other crossbreeding can be directed at the formation of a new breed based partly on the local breed. In India, the Frieswal (for milk production) is such a breed and has the benefit of a large industry capable of supporting a testing and selection scheme.

The development of new products may be a way of increasing the value of a local breed—certainly in other countries this has succeeded (special smoked mutton products and undyed woolen products have maintained a flock of Black Welsh Mountain sheep in Britain. A niche market for black fleshed chickens in Vietnam has given the Ac chicken a real potential for the future.).

Incentive payments can be used initially to assist —this was used in Myanmar for Shwe Ni Gyi where semen was subsidised and then owners were given a small amount (equivalent to $US1) when they registered the purebred calf. This allowed the population to be increased to a level where other activities could be considered. Incentive payments are used in Italy for several cattle breeds with small numbers.

Breeding schemes

When the decision is for a breeding and selection scheme there are still several different options which are open—they are not mutually exclusive but do require different levels of input. Similarly, they may well require different methods for the dissemination of improved genetic material. The options will, in part, depend upon the distribution of the breed—the number of herds, the herd size, the herd locations etc. In addition, the structure will also depend on the level of literacy, willingness to record data, ability to record certain parameters. These are obvious but not always well considered prior to the decision on the breeding structure to be adopted.

Most countries opt for a central nucleus herd or herds. This, if large enough and properly organised, is certainly likely to provide genetic progress, as evidenced by the herds operated in many 'developed' countries. However, the success in centralised, and government units appear to be limited, possibly

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because the management is not directly involved in any rewards from the success. In addition, there seems to be a tradition of placing the central unit in an environment totally different to that in which the commercial users keep their animals. A closed nucleus also has to start off with very clear plans as to the avoidance of inbreeding. This can be particularly important if traits of low heritability are to be included in the selection goal since breeding value estimation procedures use information on relatives and this may increase the likelihood of inbreeding. There are now several programs available to assist in the avoidance of inbreeding.

The Open Nucleus Breeding Scheme (ONBS) is often quoted as the preferred method of operation since, by using many base herds animals to provide a few highly selected (even if low accuracy) females as the original nucleus, there can be an immediate gain which no individual herd could have achieved. The operation then continues to accept replacement females from base herds on a regular basis (see Figure 3). There are additional benefits to the immediate genetic gain since the ONBS, if properly designed, will increase the rate of genetic change and also reduce inbreeding rate (James 1977). However, if not specifically designed for the particular circumstance, it is possible that progress is reduced (Steane et al. 1982). There are other more important issues with ONBS since these tend to be cooperative ventures—in fact, the first were all termed 'Group Breeding Schemes' (GBS) in New Zealand and Australia. It is crucial that issues of ownership of animals and progeny, terms of transfer of all genetic material, joining and leaving the group, the location and management of the nucleus are all settled legally before the scheme starts to operate. Experience indicates that without this, the major beneficiary of the scheme will be the legal profession.

However, ONBS/GBS do have some advantages other than the genetic ones. The dissemination of improved material becomes part of the whole operation, individual members can use their attributes to best advantage for all and publicity is a joint and coordinated effort. If structured properly in the Asian developing country environment, ONBS can provide considerable political protection, particularly important in long-term schemes as there is little doubt that governments in Asia are likely to move to further privatisation over the next few years. Schemes need to be started in a way which allows this transition to

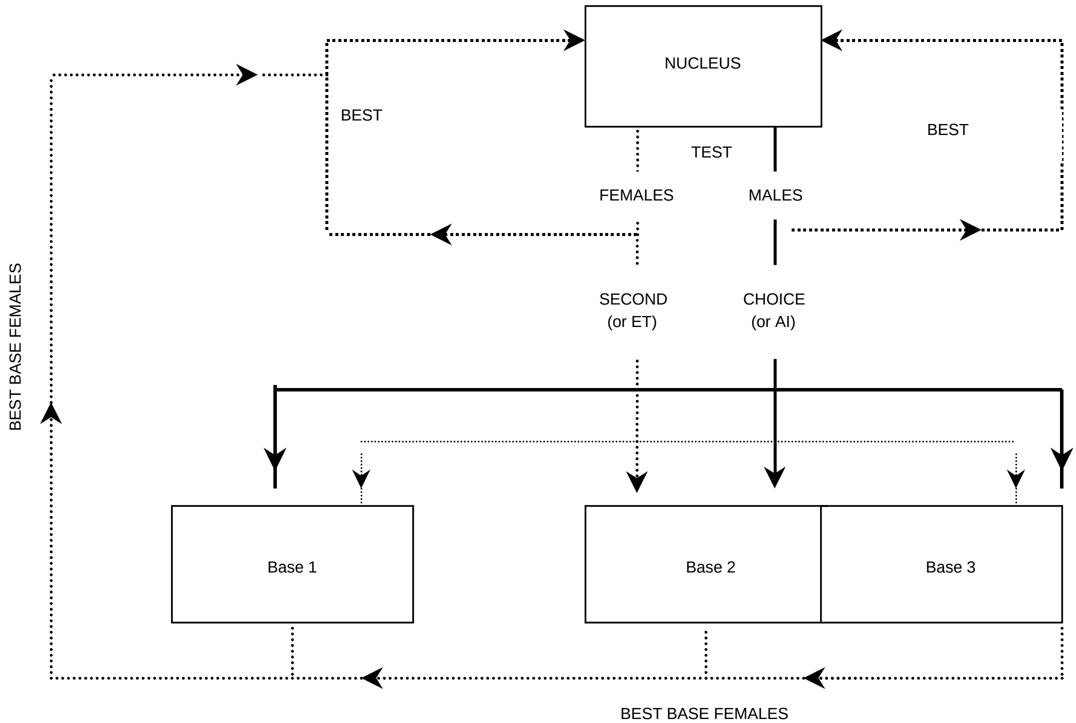

Figure 3. Open nucleus breeding scheme (ONBS).

take place without causing major upsets or indeed the abandonment of schemes.

A ‘dispersed’ nucleus can have advantages in terms of risk aversion but clearly suffer from disadvantages in genetic terms unless each herd is sufficiently large to allow good contemporary comparisons and adequate numbers of bulls and progeny to link herds well. Dispersed nuclei can be reasonably easy to operate; for example, if a breed is located in series of villages, each can be designated as a nucleus and then bulls selected in one village are sent to another (in a set sequence) so that after, say, six generations the circle is completed. This avoids inbreeding, provides genetic gain and provides each location with an incentive. While this will result in much gain by environmental adjustments, as long as these cover the whole location, it does not compromise contemporaneity and gives participants some phenotypic changes to talk about.

Where a breeding strategy involving crossbreeding for the commercial slaughter animal is practised, it is sensible to use the early parities for pure breeding and later ones for crossing. This not only reduces generation interval but also has physical benefits. This should perhaps be the approach eventually adopted in the Thai schemes and was planned for the Malaysian Kedal Kelantan program mentioned earlier.

Traits

The traits to be selected is a subject addressed by other papers in these Proceedings—suffice it to say that biological efficiency is not easy to measure even in the best of circumstances. There are many interdependent traits and, while new bio-engineering offers the long-term possibility of changing some of these, even those alterations will need to be carefully studied over several generations before even considering its adoption. Correlated responses are part and parcel of any scheme and may well dictate the type of breeding strategy adopted (cross-breeding may get over the problems of antagonistic traits in some systems). It is well documented that selection for growth will increase mature size and also calf birth weight unless specific actions are taken to avoid some or all of these consequences. There is good evidence that selection for ‘305 day’ lactation yield has increased calving interval and that selection for lifetime performance may be a preferable option (Simm and Pryce 1998). The desk studies leading to the formulation of long-term policy need to consider all these options and their implications for the industry and the market.

The recording required clearly depends on objectives and is the subject of other papers in these Proceedings. ONBS allow for different levels of recording between base units and the nucleus and can provide an overall reduction in recording costs where traits are difficult and/or costly to measure. In some schemes, simple records of frequency of calving may be adequate if the breed is part of a crossbreeding strategy to provide the product. Other traits are essential for obtaining the desired genetic change—calf birth weight and calving difficulty assessment play an important part if limits to change in these traits is an objective.

Dissemination

The strategy for passing the genetic changes to the overall population needs careful consideration prior to the event. Schemes like ONBS and Dispersed Nuclei do have some dissemination built into the design but others do not. The general assumption is that of A.I. and this is often the optimal method. However, this is not always the case—Africa is littered with derelict AI centres (Jasiorowski 1990) and Asia could well have similar experiences unless adequate preparation for dissemination is planned. The different ‘lag’ times for various options have to be carefully studied so that infrastructure can be optimised for whatever system is shown to provide the most cost effective means. The linkages with extension services and possible privatisation should not be ignored in assessing these options.

In vitro conservation

Where a breed is at risk, as is the case for many cattle and buffalo populations in Asia, it is important to carry out in vitro conservation alongside but not in place of the in vivo programs. These techniques are not alternatives but form a linked strategy. While techniques for DNA storage are now fairly well developed, they still cannot replace the more traditional methods of storage of semen and embryos. Embryos provide distinct advantages in terms of maintaining the breed genotype since they also retain the maternal mitochondrial DNA which semen does not. The techniques are well established but the major problem in almost all countries is proper sampling of material (whether it be males for semen or matings for embryos). For example, the UK, which has had conservation activities for over 25 years, has failed to carry out this aspect properly. Recommendations for proper sampling are available as are those for sampling and analysing DNA (FAO 1998). Improper sampling is a waste of time and funds and is not justifiable under any but the most extreme circumstances (major disease outbreak, war, earthquakes, etc.). The recommendations for genetic characterisation include the primers as advised by the International Society for

Animal Genetics (ISAG) and these should be followed if funds are to be spent in a fully responsible manner since their use allows global interpretation of local data. The list is available on FAO DAD-IS.

Optimisation of Production Systems

The various analyses undertaken together with the technology assessments will enable prediction and then modelling of various aspects of each system to identify potential gains and sensitivities within each system. These will further the likelihood of being able to optimise systems in terms of those criteria considered most relevant in national terms.

Policy decisions regarding long term industry structure

The studies listed earlier will enable governments to look at the implications of various options open to them in the long-term plan for the different livestock and agricultural industries. There are many considerations not all of which have direct technical bearing. The costs of infrastructure, the option to use large business or small farms as the base for expansion, the affect on costs of developing extension services, the consequences on soil structure and fertility of industrial systems in peri-urban areas relative to more rurally based approaches will have to be examined in the primary evaluations of each system considered relevant for future production. The health risks both to animals and humans of the different options must be brought to bear on the structure adopted. The realistic appraisal of the potential for export needs addressing—lessons from crops indicate that, on many occasions, too many countries aim for the same market and suffer the resulting lower value of the product. It is preferable that decisions are made prior to major investments in breeding schemes which themselves require long-term investment.

Summary

The demand for livestock products is set to continue rising at a high rate for the next 20–30 years. The ability to achieve the livestock revolution required to supply this demand centres on the full consideration of all aspects of the industry and in appropriate policies being developed.

Genetic evaluation both between breed and within breed has an important role to play in the 'Livestock Revolution' and has certain advantages but cannot be considered in isolation. In addition, annual output per animal of a specific product is not necessarily the major component of biological efficiency. The maintenance of genetic diversity is crucial for long-term sustainability and both in vivo and in vitro schemes should be considered as elements of the same policy. The use of all available resources in a manner which does not result in the reduction of and/or damage to resources for future generations is perhaps the most important consideration now required of all countries.

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Beef Cattle Genetic and Breeding Projects in Vietnam and the Future Direction

Brian M. Burns[1], Dang Vu Binh[2] and Vo Van Su[3]

Abstract

Vietnam's current and future human population estimates are presented. Present per capita ruminant and non-ruminant meat consumption is also reported. Based on this information, projected demand for meat from both ruminant and non-ruminant sources in 2010 will outstrip supply. It is estimated that Vietnam has the capacity to supply a high proportion of these projected shortfalls through improvement and development of its existing production systems. Specifically, this paper is focussed on describing the beef cattle breeds in Vietnam and their respective production characteristics. Further, factors that are preventing the development of coordinated beef cattle breeding strategies to improve productivity and profitability are identified and ACIAR and AusAID projects developed to improve the profitability of farmers' beef production systems are discussed. Finally, recommendations to ensure the future development of coordinated beef cattle breeding strategies that will assist in improving the profitability of farmers' beef enterprises are presented.

AT PRESENT, Vietnam's population is estimated to be about 78 million people. By the year 2010, the country's population is projected to exceed 100 million people (Anon. 1995). This increase in population and economic growth will increase the demand for animal protein of all types.

The UN Food and Agriculture Organisation (Anon. 1994) estimated that annual per capita meat consumption was 16.6 kg with around 2.5 kg derived from ruminants and 14.1 kg derived from non-ruminants. Between 1970 and 1994, the consumption of non-ruminant and ruminant meat increased by 2% and about 1.5%, respectively. Significantly, cattle numbers increased over the decade 1983–1993 by 5% annually to reach a population of 3.3 million head and buffalo by just under 2% to reach 3.0 million head.

In 2010, projected demand for meat from both ruminant and non-ruminant sources will outstrip supply. Production of ruminant meat (mainly beef) is anticipated to be 3 kg per capita with consumption estimated between 3.6 and 4.2 kg per capita. Equivalent estimates for non-ruminant meats are 18.9 kg and between 21.5 and 25.2 kg for production and consumption, respectively. It is estimated that Vietnam has the capacity to supply a high proportion of these projected shortfalls through improvement and development of its existing production systems.

The small Yellow Cattle and the Laisind breeds are the most common breeds of cattle in Vietnam. Yellow Cattle have low average body weights, about 180–200 kg for mature females, around 300 kg for bulls and are extremely well adapted and fertile. The Laisind breed is a result of crossing the introduced Red Sindhi breed (1920 and more recent introductions) with the local Yellow Cattle breed. Mature Laisind animals usually average about 100 kg heavier in liveweight than Yellow Cattle and are often used by farmers as a first cross when attempting to increase the size of their animals. In general, cattle are managed on a low-intensity basis, utilising mixed feed resources of variable quality. Fertility rates in these cattle are good but growth rates and profit margins are typically low. These cattle are used as sources of animal power, income and a form of wealth.

Given this background, this paper discusses the present situation in Vietnam, aspects of current beef cattle genetic and breeding projects in Vietnam and the future direction. Specifically, discussions of Sub-Project 5, Genetics and Breeding, ACIAR Profitable Beef Cattle Development in Vietnam Project (AS2/97/18) and an AusAID Capacity-Building for Agriculture and Rural Development Program (CARD) Project are presented.

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Present Situation

At present, there are a number of factors that are preventing the development of coordinated beef cattle breeding strategies. These include:

- no economic incentive for farmers to improve the performance and quality of their cattle;
- no integrated plan to develop a more efficient beef cattle industry through the identification of relevant performance trait measurements;
- no training in integrated supply chain and marketing systems;
- limited evaluation of the production performance of the local Yellow Cattle, Laisind cattle or 'Tropical Crossbred Cattle Types' on level terms in the local environment/regional beef production systems;
- no sound monitoring, recording or collection of 'standard' information on what is happening at the local level – opportunity to use information in genetic analysis at a later stage;
- no structured breeding programs with well defined 'breeding objectives'; and
- poor communication, coordination and collaboration between universities, research, development and extension (RD&E) and farmer groups to enhance the development of a National Beef Cattle Breeding Strategy.

Beef Cattle Genetic and Breeding Projects in Vietnam

ACIAR Profitable Beef Cattle Development in Vietnam Project (AS2/97/18)

As a result of the rapidly growing economy, the demand for beef, predicted to rise as incomes increase and forecasts indicating a widening gap in the supply of beef from national sources, a need was identified to raise the productivity of beef farming enterprises. Therefore, an ACIAR Project, Profitable Beef Cattle Development in Vietnam, was designed to assist in the profitable development of Vietnam's beef industry through conducting collaborative research in six key areas. These areas include:

- marketing systems;
- profitable calf management;
- forage production within intensive farming systems;
- evaluation of agro-industrial by-products as cattle feed;
- genetics and breeding;
- animal and human health.

The overall project objective has been to contribute to the profitable development of the beef industry in Vietnam through an integrated, multi-disciplinary and cooperative series of scientific activities conducted in different regions of the country and targeted to the needs of specific production systems.

An important goal of this project has been to seek outcomes which increase the profitability of cattle-rearing by smallholder farmers, rather than assessing results only in terms of physical production or productivity measures. Extensive use has been made of on-farm research wherever possible and the whole program has been employing a diverse set of research and training methodologies.

A distinctive feature has been to structure the research through a series of independently-managed, integrated sub-projects as identified above. Interdisciplinary teams have involved some common members from all of the main sub-projects to ensure that effective collaboration is maintained, both geographically and between disciplines.

In the past, institutional agencies, such as national research centres have tended to measure significant improvements in terms of more, better, larger and quicker. However, smallholder farmers have generally nominated profitability as their first concern, namely, economic performance: prices, profit and income. The measure of 'profitability' used in this project will be 'the predicted effect of an intervention on whole-farm profitability' (Perkins 1996).

Further, recommendations based on official policy or good research procedures have not been adopted by farmers. Generally, rejection has been based on economic grounds, that is, too little return for the extra inputs and effort; too great a risk for uncertain rewards and too great a lapse of time between investment and return.

A brief outline of Sub-Project 5, Genetics and Breeding is presented. A feature of this project has been the 'on-farm' research approach which has accepted the problems of measurement and replication across different farming production systems and where issues are tested by farmers with their land and resources.

Sub-Project 5, Genetics and Breeding

Objectives

The objectives of this project include:

- to undertake a critical review of the current breeding strategies of national and provincial authorities in Vietnam;
- to improve the level of understanding of modern genetic principles and reproduction and artificial breeding technologies; and
- to monitor the performance of progeny generated by crossing four tropically adapted performance-evaluated sire genotypes from Australia to Laisind dams at two experimental research sites.

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Results

The results to date include:

- The critical review of current breeding strategies in Vietnam highlighted the urgent need to overcome the misplaced emphasis on increased body size for cattle production and a long history of uncoordinated crossbreeding with exotic *Bos indicus* and *Bos taurus* breeds, much of which has yielded few lasting or useful results. Beef cattle production is a longer-term investment compared to the more intensively-fed/managed dairy industry, which yields farmers a daily income return. More thought and research is required on developing a breeding strategy for beef cattle, with clearly-stated objectives which combine farmers' preferences and official policy. As a result of this survey, this project has been focussed on developing a crossbreeding program to produce a mid-sized, 'easy care' animal with good growth and good fertility, while remaining well-adapted to the local environmental stresses.
- To improve the level of understanding of modern genetic principles and reproduction and artificial breeding technologies, two training workshops in *Genetics, Breeding Programs* and *Artificial Breeding Technologies* were organised at Ba Vi Research Station, Ba Vi, Ha Tay Province, north-west of Hanoi and at Buon Ma Thuot and M'Drak, Dak Lak Province in the Central Highlands of Vietnam.

Approximately 20 participants attended each workshop where an 'adult education' training strategy of 'learning by doing' was employed, as the workshops were attended by people with various levels of training in the disciplines of genetics and animal breeding. After brief presentations on theory, the participants were then asked to apply the principles that they had just learnt about through working examples or through actual training on cows organised by staff from the National Institute of Animal Husbandry. Further, the workshop focussed on both the similarities and differences that exist between tropical northern Australia and tropical Vietnam, and then technologies/strategies that might be applied in Vietnam were discussed.

With the completion of the theory and practical components of the course, participants were encouraged to contribute to the planning of a successful artificial breeding program, that is Objective 3, at their respective locations, so that they had both ownership of the problems confronting the particular program in their region and of the solutions to these problems. This approach received overwhelming support, with the result that all participants wished to have some involvement in the proposed crossbreeding programs at the two sites.

On the final day of each workshop, potential collaborating farmers were invited along to the workshop to listen to and discuss the objectives of the proposed project, the proposed tropical breeds of beef cattle to be used in the project and any concerns that they might have with respect to the production and evaluation of these crossbred calves. Once again, this proved to be a very successful strategy. The farmers were comfortable with this approach and they openly discussed all issues with both the workshop participants and trainers.

Further, to ensure the success of this project, additional presentations were made to the provincial leaders of the Departments of Agriculture and Rural Development (DARDs) so that they were aware of the objectives of the project, had some ownership of the project in their province and also had the opportunity to explore the potential of integrating this project with already existing provincial projects. As a result of this strategy, the provincial leaders of the DARDs pledged their support to ensure a successful conclusion to the project.

- To monitor the performance of progeny generated by crossing four tropically adapted performance-evaluated sire genotypes from Australia, by artificial insemination (AI), to Laisind dams at two experimental research sites has been the greatest challenge in this project.

In Vinh Phuc Province, North-West of Hanoi, the following breeding program was employed:

Red Brahman (100% tropically adapted *Bos indicus*) (AI) sires	× Laisind dams
Droughtmaster (50% tropically adapted *Bos indicus*) (AI) sires	
Red Brangus (50% tropically adapted *Bos indicus*) (AI) sires	
Laisind sires (natural mated)	

At M'Drak, in Dak Lak Province, Central Highlands of Vietnam, the following breeding program was employed:

Red Brahman (100% tropically adapted *Bos indicus*) (AI) sires	× Laisind dams
Droughtmaster (50% tropically adapted *Bos indicus*) (AI) sires	
Belmont Red (tropically adapted *Bos taurus*) (AI) sires	
Laisind sires (natural mated)	

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During the second phase of this project, AI training courses were run to evaluate the skills of the Vietnamese Research and Extension (R&E) staff. In addition, Vietnamese R&E staff organised training days in heat detection for the cooperating farmers to ensure that cows could be successfully identified for AI.

Representative calf breed types have been produced and their growth performance will be evaluated towards the end of 2001 using a high molasses based diet in conjunction with a true protein and roughage.

AusAID CARD Project – 'Enhancing Tropical Beef Cattle Genetics, Reproduction and Animal Breeding Skills as Applied to Beef Industry Supply Chain Systems'

The focus of this project has been to enhance the local capacity for teaching, research and extension in agriculture and rural development in the key priority area of agriculture, and livestock improvement in Vietnam, and within these areas, to deliver activities in the disciplines of biotechnology and genetic improvement as highlighted as a priority area by the Government of Vietnam (GOV) in the Vietnam–Australia Development Cooperation Program, CARD Program Guidelines. Specifically, this project has focussed on specialised training, in Australia and Vietnam, and curriculum development in Vietnamese universities and associated agricultural institutions, in the disciplines of genetic improvement, reproduction and animal breeding.

Objectives

The objectives of this project include:

- short-term R&E staff placements in tropical central Queensland, Australia ('train the trainer' strategy);
- three strategically located workshops conducted throughout the northern, central highlands and central coastal regions of Vietnam (use of Australian specialists and Vietnamese R&E staff trained in Australia, as identified above); and
- curriculum development exercises in Vietnamese universities and associated agricultural institutions.

A final objective of this project has been to enhance the Sub-Project 5, Genetics and Breeding, ACIAR Profitable Beef Cattle Development in Vietnam Project (AS2/97/18). To date, this sub-project has been progressing well and has offered many active learning opportunities for project staff. However, this ACIAR project has a research focus and the project team has not been able to extend the successes of this project to the wider farming community.

Results

The results from this project include:

- Ten Vietnamese R&E staff visited the tropical beef cattle production region of central Queensland, Australia, and received specialist training in R&E techniques and strategies in tropical genetics, animal breeding and reproduction and visited all sectors of a tropical beef industry supply chain system.
- Three training workshops in 'Tropical Genetics, Reproduction and Animal Breeding' were developed, organised and conducted in the North, Central Coastal and the Central Highlands regions of Vietnam. These workshops:
  - ➢ included the production of course notes in English and translated into Vietnamese;
  - ➢ were centred on regional farmer groups/communities involved in the established ACIAR Genetics and Breeding Sub-Project sites in Vietnam; and
  - ➢ employed a 'regional beef cattle production systems approach' that:
    - ◆ used collaborative and consultative group strategies between Australian and Vietnamese R&E specialists working together with these farmer groups to identify their concerns/issues with respect to profitability and sustainability of their beef cattle enterprises,
    - ◆ resulted in more targeted R&E strategies that effectively addressed these issues, promoted local ownership of both problems and solutions by all members of farming families and communities and R&E specialists through this approach resulting in increased adoption of 'best practice' management strategies; and
    - ◆ assisted in the alleviation of poverty in the these local collaborating farming communities, as a direct result of implementation of this 'regional beef cattle production systems approach'.

A feature of these workshops, as identified above, was activities centred on regional farmer groups at established ACIAR Genetics, Breeding and Reproduction Sub-Project sites throughout Vietnam employing Australian and Vietnamese extension specialists, working together with these farmer groups, to identify their concerns/issues with respect to profitability and sustainability and to ensure that future research would be based on identified 'issues' – 'issues-based research'.

- A new curriculum in 'Tropical Genetics, Reproduction and Animal Breeding' will be developed in collaboration with Vietnamese universities and

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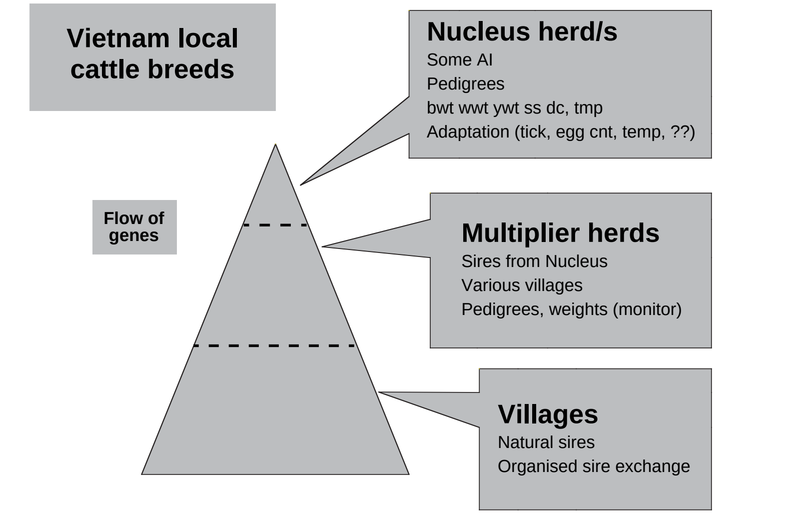
associated agricultural institutions, and agreed to by these organisations.

These activities will result in the development of a strong framework for future growth forged through the delivery of modern genetic principles applied to the development of practical animal breeding strategies and delivered through the latest reproductive technologies.

Recommendations for Future Direction

There are a number of recommendations that have been identified to ensure the development of coordinated beef cattle breeding strategies that will assist in improving the profitability of farmers' beef enterprises. These include:

- Universities, RD&E groups and farming communities/families
  - ➢ Encourage interactive and participatory approach between these groups in problem solving.
  - ➢ Develop a 'two way' flow of information between these groups.
  - ➢ Foster a collaborative and coordinated approach in the collection and management of 'standard' data.
  - ➢ Promote the development of a sound National Beef Cattle Recording Scheme.
- Foster a Regional/Whole of Commune Beef Cattle Production Systems Approach
  - ➢ Define the 'Regional Beef Production System'.
  - ➢ Define the environment.
  - ➢ Ensure a sustainable production system
    - ◆ Resources available for future generations (soil and vegetation).
    - ◆ Cost of production/Maximise profit (factor in all costs and returns).
    - ◆ No one 'best regional/national system' with respect to replacement animals and sale animals.
    - ◆ Investigate the opportunity for integrated/ 'alliance' type systems, for example, seedstock producers, commercial breeders and finishers.
  - ➢ Market definition.
  - ➢ Investigate and promote payment on final liveweight or slaughter weight.
  - ➢ Develop management strategies
    - ◆ Finishing strategies
    - ◆ Weaning strategies
    - ◆ Disease management strategies
    - ◆ Breeding cow herd\Bull management.
  - ➢ Genetic improvement program (bull selection)
- Develop a permanent and unique animal identification system.
- Develop customised 'Regional/Commune Breeding Objectives' and a National Breeding Strategy (Figure 1.)



- Farmers who are prepared to 'change' and cooperate are the ones who usually move to the top of the breeding structure and others move to the bottom.

Figure 1. National breeding strategy.

- ➢ Criteria:
  - ◆ Well adapted;
  - ◆ Good fertility;
  - ◆ Mid-sized;
  - ◆ 'Easy care';
  - ◆ Good growth;
  - ◆ Combination of farmers' preferences and official policy.
- Develop an Economic Selection Index = $w survival + $x fertility +y rate of gain.
- Need to start with manageable sites. Need to work with farmer groups who are prepared to 'change' and improve their production system rather than trying to change the whole country.

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The Influence of Brahman Genetics in the Australian Cattle Industry

John Croaker[1]

Abstract

The growth and development of the Australian Brahman has been described as the greatest livestock revolution in history. Using technologies such as BREEDPLAN, AI and ET to improve the rate of genetic gain, has increased the impact of Brahman genetics from being a crossbreeding option to the largest pure breed in the country. With the Brahman cross and derived breeds increasing to 35.5%, the Brahman influence now impacts on more than half of the Australian herd. Beef markets available to Australian producers range from the 180–240 kg domestic supermarket trade to 300–420 kg grain fed export markets. Live cattle exports for 2000 numbered almost 900,000 head. The introduction of Brahman genetics into the Australian cattle industry was in itself applying technology to make change.

THE INTRODUCTION of Brahman cattle into Australia is an excellent example of the way technology can change an industry.

The history of Brahman type cattle in Australia goes back more than 200 years to the early days of colonisation. However, these cattle had no impact on the industry we know today.

Dr J.A. Gilruth, a veterinarian who, after a period as Administrator of the Northern Territory became chief of the new division of Animal Health in the Council for Scientific and Industrial Research (CSIR), concluded after a tour of Texas USA in 1920 that 'vigorously controlled cattle breeding experiments in North Queensland would be wise'.

When preparing a research program for CSIR in North Queensland, he included a proposal 'for an enquiry into Zebu crossbreeding experiments carried out by the United States Bureau of Animal Industry and others in the southern US states.

The enquiry was carried out by Dr R.B. Kelly who concluded that Brahman crossbreeds:

(1) matured earlier;
(2) grew and finished on inferior pasture;
(3) had a two to three percent carcass yield advantage;
(4) had a high drought survival rate; and
(5) carried relatively few ticks.

A project to import Brahman cattle eventuated in 1933 with the co-operation of three Queensland pastoral companies and one individual grazier. The syndicate imported 18 head in the 1933 shipment which was put together by Dr Kelly. On arrival, the cattle were divided among the syndicate members and used in breeding trials controlled by the CSIR.

Sale of progeny was not permitted in the early stages; however, the results of the trial were so successful sales did eventuate in spite of stiff opposition from many traditional graziers.

In 1946, two north Queensland graziers, Mr Ken Atkinson of Wairuna and Mr Maurice de Tournouer of Wetherby, Mt Malloy, who had bought cattle and joined the syndicate, decided to form the Australian Zebu Breeders Association. Shortly afterwards, the name was changed to the Australian Brahman Breeders' Association.

Membership grew slowly as the availability of Brahman cattle was limited.

The CSIR became the CSIRO (Commonwealth Scientific and Industrial Research Organisation) and continued research into the mechanisms of adaptation which made the Brahman a superior animal for northern Australia.

Further importations followed in the early 1950s and by 1954, 49 head had been imported. Importations were terminated in 1954 because of blue tongue in the USA. Health protocols changed in 1981 and since then more than 700 animals have been imported.

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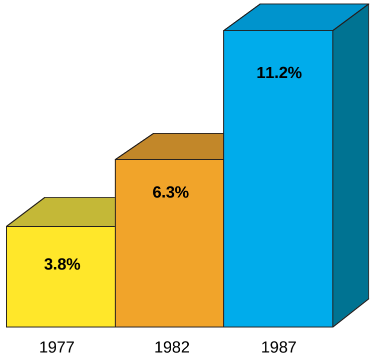
The initial objective was to use the Brahmans for cross breeding with no thought to establishing them as a major breed in their own right. This changed as cattlemen recognised the improvements in productivity they achieved as the cattle continued to be upgraded towards a pure Brahman.

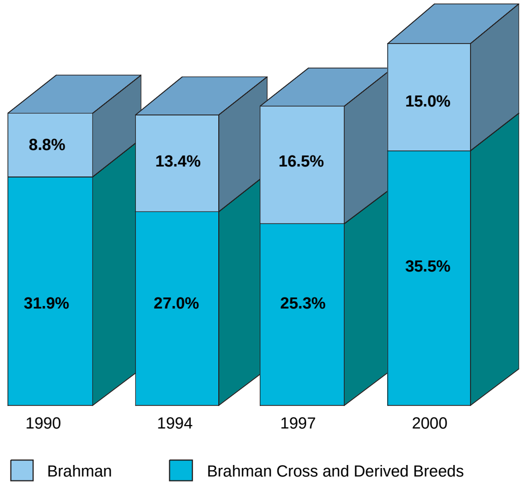


Source: Australian Bureau of Statistics

Figure 1. Brahman cattle as percentage of the QUEENSLAND cattle herd.

By 1973 their numbers had reached 226,400, 2.5% of the Queensland cattle herd. Numbers continued to grow and in 1987 the Brahman population exceeded 1 million head which was 11.2% of the State's beef cattle herd.

Accurate statistics on the break up of the Queensland cattle herd were last collected in 1987. Since then, the industry has relied on surveys conducted by

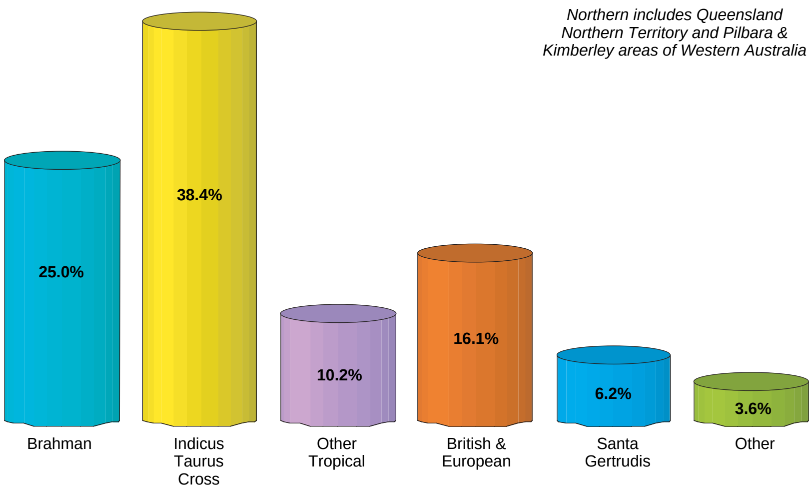


Source: Australian Bureau of Agriculture and Resource, Economics Australian Farm Surveys derived from interview and statistical extrapolation

Figure 2. Brahman, Brahman Cross and Derived Breed cattle as percentage of the AUSTRALIAN cattle herd.

the Australian Bureau of Agricultural and Resource Economics which, although useful, are not as robust, due to sample error.

Brahman cattle were estimated to be 8.8% of the population in 1990 and influencing another 31.9% through crossbreeding and Brahman derived breeds such as Brangus, Braford and Charbray etc. In the 10 years to 2000, their numbers are estimated to have



Source: ABARE Australian Farm Survey

Figure 3. Estimated beef herd composition in northern Australia — 2000.

almost doubled to 15%, making them the largest purebred in the country. With the Brahman cross and derived breeds increasing to 35.5%, the Brahman influence now impacts on more than half of the Australian herd.

In the northern industry, which includes the states of Queensland, Northern Territory and the Pilbara and Kimberley areas of Western Australia, the percentage is almost 74%.

North of the Tropic of Capricorn, the impact of the Brahman is highlighted by the fact that an estimated 110,000 or 70% of the bulls servicing the industry in this part of the country are Brahman.

The Australian Brahman Breeders Association (ABBA)

The ABBA has over 1100 members and is the largest beef cattle breed association in Australia. It registers and records over 26,000 new animals annually which is among the highest recording activity of any of the beef breed associations. The association maintains a state-of-the-art computerised pedigree and performance database which contains pedigree records on over 500,000 animals — Brahman BREEDPLAN.

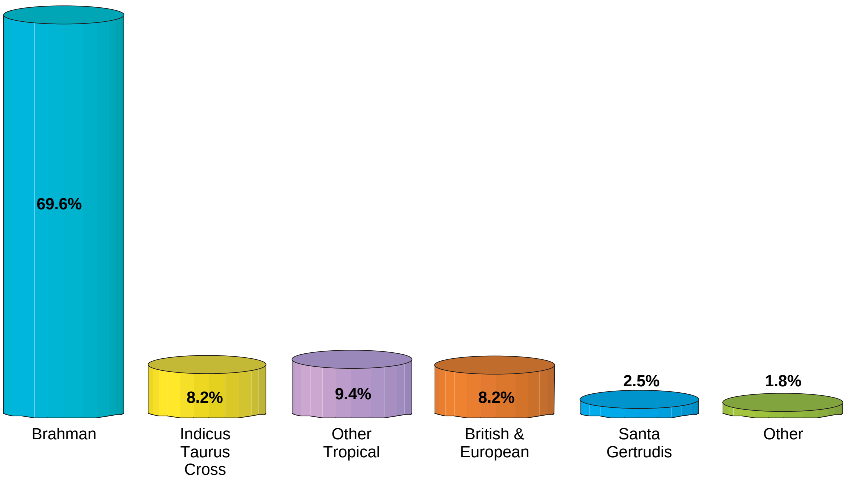
The 4 economic drivers of beef production in northern Australia are:

- survival;
- reproduction;
- weight gain;
- carcass and meat quality.

Survival requires adequate adaptability for the production environment and attention to structural soundness which is easily recognisable with visual appraisal and somewhat difficult to build into an objective analysis.

Reproduction is assessed in the Brahman BREEDPLAN system by two traits, scrotal circumference as an indicator of male fertility and days-to-calving, as an indicator of female fertility.

Growth is represented in our analysis by 5 traits — 200-day milk, 200-day growth, 400-day growth, 600-day growth and mature weight. The combination of these traits contributes to the accuracy of the analysis through the correlation between the traits and it



Source: ABARE Australian Farm Survey

Figure 4. Estimate of bulls on broadacre properties north of the Tropic of Capricorn — 2000.

Table 1. Traits reported in Brahman breedplan.

Growth	Carcass	Fertility
200 day milk	Carcass weight	Scrotal circumference
200 day growth	Eye muscle area	Days to calving
400 day growth	Rib fat	
600 day growth	Rump fat	
Mature weight	Intra muscular fat	

also provides some differentiation between earlier maturing and later maturing animals.

Carcass and meat quality in our markets basically means yield; therefore, the traits we are mainly concerned with are carcass weight, eye muscle area, rib fat, rump fat and retail beef yield.

Intra muscular fat has been included and may become more important in the future if processors develop value-based payment systems which include marbling.

Utilisation of Brahman BREEDPLAN

BREEDPLAN has been used in the Australian Brahman industry since its inception in 1983 through the National Beef Recording Scheme (NBRS). Usage levels were low and duplication of input data was a major disincentive.

In 1990, the NBRS and ABBA files were merged and the Brahman BREEDPLAN pedigree and performance database was created. Our first sire summary was published in 1991. It contained the analysis of 105 sires and 14,104 dams in eleven herds and 32,201 weight records.

During 2000, group BREEDPLAN analyses included 7543 sires, 52,755 dams in 47 herds and 167,695 weight records.

While the number of participating herds may seem low, they represent more than one third of the Association's calf recordings because most of the major herds are involved.

In 1999, the Australian Registered Cattle Breeds Association (ARCBA), prepared a report on the impact of BREEDPLAN throughout the industry by extracting data on active cows.

Table 2. 2000 Brahman group BREEDPLAN run statistics.

Trait	No. of records	Avg. adj. wts
200 day weight	78,981	199 kg
400 day weight	38,492	267 kg
600 day weight	47,537	370 kg
Mature weight	2684	499 kg
Total number of weight records	167,695	
Scrotal circumference records	7115	
Adj. avg.	27.25 cm	
Scan carcass data records		
12/13 Rib fat	6604	2.58 mm
Rump fat	6680	4.04 mm
IMF%	254	2.74%
EMA heifers	2957	50.2 cm
EMA bulls	3639	68.1 cm
Abattoir carcass records	5467	
Total number of sires	7543	
Total number of dams	52,755	
Number of herds participating	47	

Table 3. Estimated number of active cows and BREEDPLAN cows for the brahman breed in 1999.

Herd size	Estimated no. of active cows	Estimated no. of BREEDPLAN cows	% of group	Cumulative %
250 +	7657	5991	78.2	78.2
150–250	3574	1455	40.7	66.3
100–150	2376	1013	42.6	62.2
50–100	4598	734	16.0	50.5
25–50	3360	498	14.8	44.9
<25	4342	104	2.4	37.8
Total	25,907	9795	71.4	

Total number of herds with inventory 749
Total number of BREEDPLAN herds 58 (7.7%)

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This research showed that the larger more influential herds are using BREEDPLAN. In fact, 78.2% of the cows in herd size of 250 and above are in BREEDPLAN (Table 3). Overall Brahman participation was 37.8% which is similar to the European breeds.

For a number of practical reasons, mainly created by poor seasons, participation in BREEDPLAN in the early 1990s was lower than anticipated. However, since 1998, the participation rate has increased, mainly due to the Association's involvement in the Tropical Cattle Technology Services (TCTS) project. TCTS is a project funded by ABRI, Meat and Livestock Australia and all of the tropical breed associations to employ a technical officer. The project has been managed by Richard Apps since its inception and he has been able to more than double the utilisation in almost all of the breeds involved. By working directly with members, he has been able to not only increase the volume of recording but also to improve the quality of the data on initial entry. In many cases, this has included the uptake of historical weight records used for performance ratio analysis by members.

Sire Summary

Our Sire Summary is published annually and reports on all of the traits described previously in a document which is inserted into our magazine and distributed to more than 2200 cattle producers, agents and industry support services throughout Australia.

Web application www.brahman.com.au

In addition to the printed material, our entire database of pedigree and performance information is available on the internet 24 hours a day, 7 days a week.

The information is interactive and able to be searched using very powerful search engines and is updated on a weekly basis.

Genetic trends

The genetic trend for the weight gain traits are clearly evident from the increase in the average EBV for the various weights over time (Figure 5).

Prior to 1983, performance recording was based on selection using ratios and it can be clearly seen when this back data were re-analysed in the BREEDPLAN system in 1983 that very little if any progress had been made.

Since 1983, the genetic trend for all growth traits has been positive with the exception of milk where no selection pressure for improvement has been made because of the negative correlation between

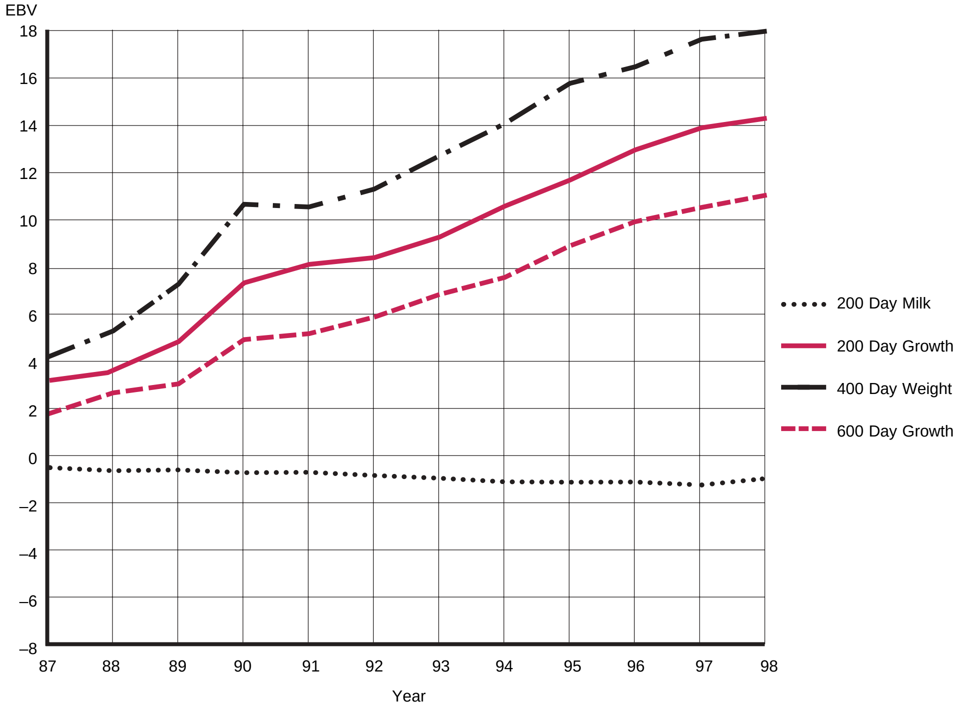

Figure 5. Average estimated breeding values (EBVs) for calves since 1987.

increased milk and female reproduction in our production environment. Brahman cattle have sufficient milk to adequately rear a calf; therefore, it is not a selection priority for this trait to be increased.

The value of using high EBV bulls as well as the accuracy attached to the EBV has been confirmed on a number of producer demonstration sites in Queensland using Brahman bulls.

The most recent of these was hosted by the McClymont Family at Bourketown, North Queensland.

Ten Brahman bulls selected on 600-day EBVs were used by AI randomly over heifers. The 5 high EBV bulls had an average 600-day EBV of +27.4 kg. The 5 low EBV bulls had an average 600-day EBV of –12.6 kg.

The high EBV bulls' average was 40 kg above the low EBV bulls; therefore, BREEDPLAN predicts the progeny of the high EBV bulls to weigh 20 kg heavier at 600 days (about 19 months).

The progeny of the high EBV bulls were on average:

- 1 kg heavier at weaning;
- 15 kg heavier at 10 months of age;
- 22 kg heavier at 19 months of age;
- 31 kg heavier at 31 months of age;
- 41 kg heavier at 40 months of age.

At slaughter, the progeny of the high EBV bulls returned an average of $41 per head more than the low EBV bulls. The results from the trial showed that the performance of the progeny was very close to that predicted by the EBVs and the magnitude of difference between the two lines increased with age.

AI and ET utilisation

A total of 27,284 animals were calf recorded from July 1, 2000 to June 30, 2001. BREEDPLAN members were responsible for 51% of these recordings. This figure is slightly inflated as some new BREEDPLAN members have input some historical data.

A total of 1030 (3.77%) of the calves recorded were produced by embryo transfer (ET) and 3004 (11%) were by artificial insemination (AI).

BREEDPLAN members were responsible for 51% of ET activity and 55% of the AI recordings.

The ET activity is restricted to use with elite or high priced females as the technique is still relatively expensive.

AI use is basically restricted to use with heifers. This is because it is not practical in most situations to run AI programs with lactating females because of the difficulty detecting heat in extensive grazing situations and an extended calving period which usually continues for at least 5 months.

Flow of Genetics

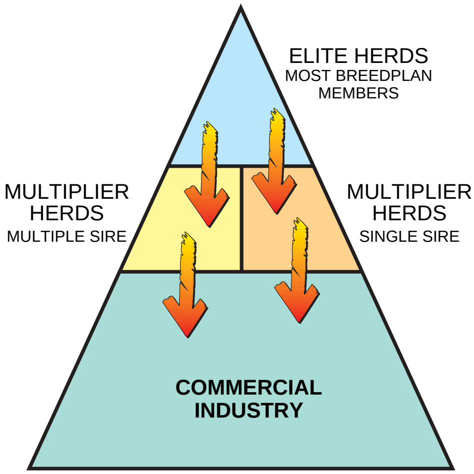

Figure 6. BREEDPLAN flow chart.

The structure of the Brahman seedstock industry in Australia is the classic triangle (Figure 6) with the elite herds at the top producing animals that pass on to multiplier herds. The multiplier herds come in two forms. They can be other stud breeders using single sire breeding methods or alternatively multiple sire herds.

Some of the elite herds also run multiplier herds as part of their production system. Most of the elite herds are members of BREEDPLAN and it is this sector of the industry where most of the critical selection takes place.

The Australian Beef Industry

The Australian cattle herd is estimated to be 26.5 million head, half of which is in northern Australia (Figure 7).

Australia has about 2% of the world cattle population, yet it is responsible for 21% of world beef trade (64% domestic production). Total slaughtering for 2000 excluding calves amounted to 7,519,100 head (Table 4).

Table 4. Australian beef and veal exports for 2000 (851,978 tons. 47 different countries).

Major destinations	
Japan	326,009
USA	311,708
Korea	68,866
Taiwan	28,964
Other Asia	47,193
Canada	35,731
EU	7,441

Figure 7. Australian cattle numbers.

Table 5. Market specifications required in the Australian beef industry.

	Carcass weight range	P8 fat range	Dentition	Marbling requirement
Domestic supermarket	180–240	5–12	0 & 2T	0
Hotel and restaurant	230–280	5–12	0 & 2T	0
Korean	180–280	7–22	0–6T	0
EU	240–320	7–22	0–4T	0
Grass-fed Jap	300–400	7–22	0–6T	0
100 D Jap grain	300–400	7–22	0–6T	0
Long-fed Jap grain	300–420	7–22	0–6T	YES

Australian market specifications

Beef markets available to Australian producers range from the 180–240 kg domestic supermarket trade to 300–420 kg grain fed export markets.

All markets have weight, fat and dentition specifications and the long fed Japanese grain fed market also has a requirement for marbling.

Australian live exports

Live exports are an important and growing market for the Australian cattle industry, particularly in northern areas. Previously cattle bred in the north were transported south for fattening. The emergence of the live export market has turned what was previously a 20 c/kg discount because of freight into a 20 c/kg premium because the production areas are closer to the export ports.

Live cattle exports for 2000 numbered almost 900,000 head (Table 6). The Asian currency crisis has had a major impact on the trade. However, the BSE and FMD concerns in Europe resulted in markets in the Middle East and North Africa switching to Australian cattle. Growth is expected to continue with increased numbers going to Indonesia and the Philippines, once they achieve political and economic stability. Emerging market opportunities exist in Mexico, Thailand, Vietnam and China.

Table 6. Australian live cattle exports.

Destination	2000	1999
Indonesia	296,252	158,482
Philippines	223,774	269,572
Malaysia	56,397	65,203
Japan	14,333	12,362
Libya	0	23,115
Egypt	208,099	241,200
Middle East	61,712	48,728
Brunei	19,094	17,413
Mexico	9,594	7,701
Others	6,089	1,099
Total	895,344	844,875

Australian feedlot industry

The Australian feedlot industry has a capacity of 853,127 head. The greatest capacity is in Queensland, followed by New South Wales (Table 7).

Table 7. Australian feedlot capacity, September 2000.

New South Wales	294,165
Queensland	403,602
Victoria	63,857
Western Australia	45,463
South Australia	46,040
Australia — Total	853,127

Feedlot activity is largely directed at the Japanese export market with 60% of activity followed by the domestic market with 40% (Table 8). Feedlot utilisation varies depending on market prices for beef and feed costs and rarely operates at near 100% of capacity. Utilisation in 2000 was about 75%. While the feedlot industry is important for some markets the turn off from feedlots represents only 8.6% of total slaughterings.

Table 8. MLA/ALFA survey of feedlot activity.

Intended market destinations, September 2000		
	Numbers	%
Japan	383,120	60
Korea	19,937	3
Other Export	6,376	1
Domestic	231,038	36
Unknown	3,566	1
Total	644,039	100

The production environment

With almost half of the Australian cattle herd run in northern areas and more than one third north of the Tropic of Capricorn, Australia has strong synergies with the environmental conditions in most south east Asian countries.

Conclusion

The growth and development of the Australian Brahman has been described as the greatest livestock revolution in history.

It has transformed struggling enterprises from near bankruptcy to efficient and profitable enterprises capable of financing multi-million dollar property development and contributing billions of dollars to domestic and export income.

The introduction of Brahman genetics into the Australian cattle industry was in itself applying technology to make change. Using technologies such as BREEDPLAN, AI and ET to improve the rate of genetic gain has increased the impact of Brahman genetics from being a crossbreeding option to the largest pure breed in the country.

The fact that 70% of the bulls servicing the industry north of the Tropic of Capricorn is testament to the breed's success, not only through its suitability for the production environment but also the requirements of the domestic and export markets.

The L13 Alliance — Meeting the Future Challenges of Livestock Production

P.A. Rickards[1]

Abstract

The Agricultural Business Research Institute at the University of New England, Armidale, NSW is proposing to extend to a number of other countries the use of a genetic database (BREEDPLAN) in which genetic and breed performance data are pooled to produce estimated breeding values (EBVs) which can be used to make selection decisions during cattle breeding. Thirteen countries, Australia, Bangladesh, China, Indonesia, Laos, Malaysia, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam, Cambodia and India could be included in the system which could be expanded to include dairy cattle, buffalo and small ruminants. The move is aimed at increasing the supply of beef for human consumption in a situation where populations levels are rising, yet livestock populations are dwindling.

THE International Food Policy Research Institute (IFPRI) in its paper 'Livestock to 2020 — The Next Food Revolution' predicted that:

- The world is entering a livestock revolution that is demand led;
- Compared with 1983, meat and milk consumption will roughly double by 2020;
- Beef will become the most significant meat import of developing countries by 2020, at 2.7 million metric tons net.

For environmental reasons, we can not aim to meet this increasing demand by doubling livestock numbers. We need to run smarter livestock industries that have greater productivity per animal. A number of factors contribute to productivity including genetics, nutrition, animal health and management. This workshop is examining the opportunities for improvement through genetics.

Enter the L13 Alliance

The 13 countries that ACIAR have brought together in this Workshop in Khon Kaen will play a pivotal role in the future of the world's ruminant production, as shown in Table 1.

The participants at the Khon Kaen conference demonstrated their capacity to work together to seek solutions to common problems. It would be very advantageous for this active liaison to continue under the umbrella of what would appropriately be called the 'L13 Khon Kaen Alliance'.

Table 1. Key statistics of 13 countries participating in Khon Kaen Workshop.

Item	Combined population	Percentage of world total
Human population	3.1 B	50%
Cattle	382 M	30%
Buffalo	152 M	94%

Countries included Australia, Bangladesh, China, Indonesia, Laos, Malaysia, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam, Cambodia and India.

Example of the challenge

A dramatic example of the challenge we face has been provided in the country report for Thailand.

- Beef cattle numbers are down from 7.6 M to 4.9 M in the past 4 years (down by 35.5%);
- Buffalo numbers are down from 3.7 M to 1.2 M in the past 5 years (down by 67.5%);
- The human population is around 63 M and increasing;
- Demand for red meat is increasing.
- This means that the gap between demand for red meat and the domestic supply is widening each year.

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It is possible for the L13 Alliance to meet the challenge

There are examples of how cattle enterprises and industries in the region have been able to make substantial increases in productivity. A noteable one is the Australian Agricultural Company which runs over 300,000 head of cattle in Northern Australia. In a period of five years in the 1990s, this company was able to double its output of beef. Key ingredients to this were:

i) better breeding;
ii) better nutrition;
iii) turning off slaughter cattle at an earlier age; and
iv) running more breeding females, as a consequence of (iii).

But, as predicted by IFPRI, the human population growth in developing countries will still cause them to be major importers of beef.

However, by members of the L13 Alliance working closely together, it will be feasible to meet the overall demand for beef. A good example is the Philippines. It has a small cattle population of around 2.3 M head and a human population of around 75 M head increasing at 2.3% pa. By importing some beef and over 200,000 live cattle per year for growing out, the Philippines has been able to increase its population of cattle marginally each year. Through an ACIAR project, the Government of the Philippines is now introducing BREEDPLAN to the nucleus breeding herds so that the productivity of local cattle can be increased.

Performance recording

Most of the L13 Alliance countries are recording some performance of beef cattle and buffalo in their elite breeding herds.

However, as has been shown by the Thai BREEDPLAN project, the exercise of simply capturing performance records will not, in itself, cause livestock improvement. This only happens when the records are analysed (as in BREEDPLAN) and the resultant Estimated Breeding Values (EBVs) are used to assist in making selection decisions.

There is considerable scope for pooling performance records across a number of countries to improve genetic selection. For example, Figure 1 shows how ten of the *Bos taurus* breeds that are run in both New Zealand and Australia have their data pooled for genetic evaluation on BREEDPLAN.

The ten breeds involved all use BREEDPLAN software for collecting performance records in both Australia and New Zealand. These data are therefore collected to common standards in both countries. At least once per year, the data from both countries are pooled for each breed and across-country genetic evaluations are done. The advantages of this approach are:

- comparable EBVs are produced across countries for each breed, making selection decisions easier where animals are from the other country;
- with more data in the evaluation the accuracy of EBVs is higher;

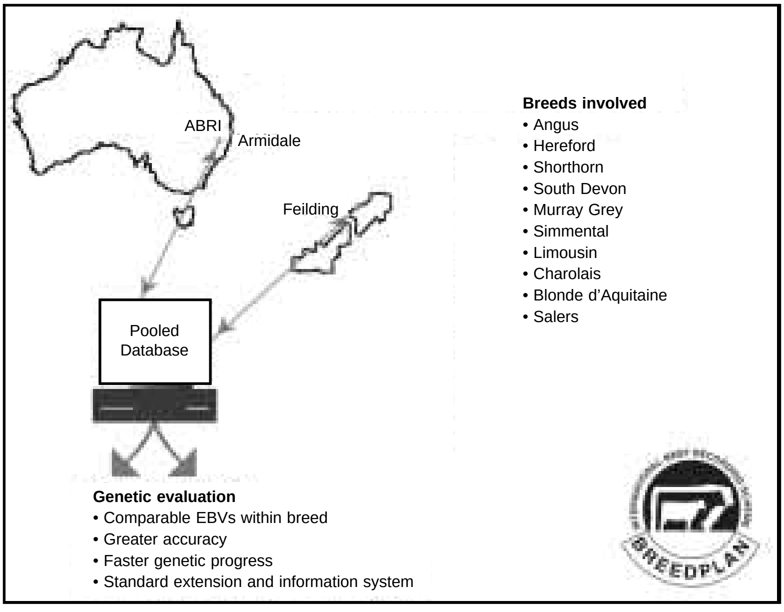

Figure 1. Regional genetic evaluation approach — Trans Tasman.

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- more data and higher accuracy EBVs means that its possible to identify and use more readily the elite genetics that increases the rate of genetic progress;
- with producers in both countries using the same recording and genetic evaluation system it is possible to achieve economies of scale in use of a common extension material; and
- more cattle breeders benefit from the research and development that underpins the common genetic evaluation system.

This trans-Tasman approach could be extended across a number of Asian members of the L13 Alliance as shown in Figure 2.

In Figure 2, the countries shown as pooling data are for illustrative purposes. Any of the L13 countries could pool data.

To achieve this it would be necessary to:
- run national databases on BREEDPLAN software;
- set up genetic linkage between countries, through use of semen from link sires for example;
- pool data for genetic evaluation.

The ACIAR-funded computer system installed in Bangkok could be used as the central processing system initially. Not only could it run across-country evaluations, but it could also act as a central data processing unit for other countries beginning the development of their pedigree and performance strategies. Thai staff would be able to offer support to neighbouring countries in establishing these systems if required. Overall supervision from ABRI staff with expertise in BREEDPLAN would be required.

In doing these evaluations, the latest version of BREEDPLAN permits introduction of EBVs calculated on sires that have been evaluated in Australia but are used in other participating countries. The advantages of this approach for *bos indicus* cattle and for buffalo in Asia are as for those described above in the trans-Tasman evaluations of *bos taurus* breeds. Benchmarking the performance of animals in various Asian environments should be an urgent objective of the L13 group.

Importantly, across-country evaluations can be extended to dairy cattle, buffalo and small ruminants. The ACIAR project just starting in the Philippines is researching this extension.

The future

There are great opportunities to improve livestock production across the L13 alliance by working collaboratively with technologies such as BREEDPLAN. ACIAR is to be congratulated for its foresight in bringing this workshop together. I hope it is the start of an ongoing dialogue between the participating countries on ways of maximising breed improvement to meet the challenges of the livestock revolution.

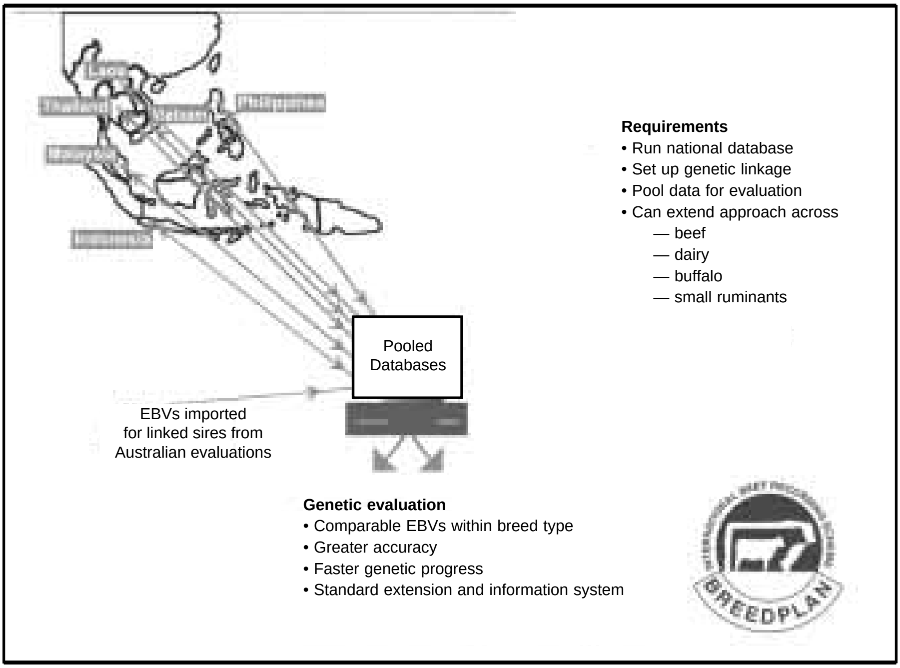

Figure 2. Potential approach to genetic evaluation by L13 participants.

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Annexe

INTERNATIONAL LIVESTOCK REGISTER
… the World's Leading Livestock Recording Scheme

The ABRI

The Agricultural Business Research Institute (ABRI) in Armidale NSW now provides its International Livestock Register services to over 60 breed Associations and government-run breeding programs world wide.

Our service is supported by a team of 180 people including scientists, agribusiness experts, marketing specialists, software developers and field staff. The composition of this team is shown in Figure 1.

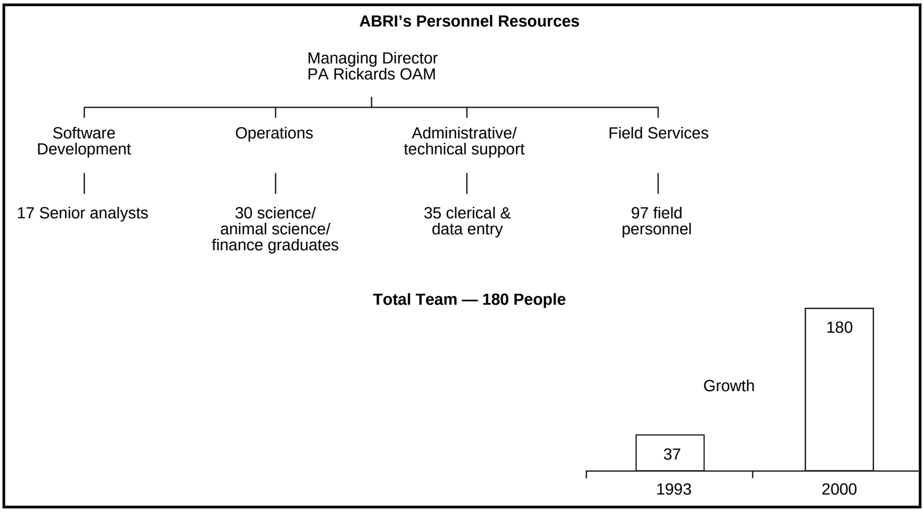

Figure 1. Personnel resources of ABRI and the growth of the team since 1993.

The growth of this team has been spectacular from 37 in 1993 when ABRI incorporated as a company limited by guarantee to 180 in the year 2000.

In addition, ABRI has commercialisation rights for much of the technology coming out of the University of New England-based Animal Genetics and Breeding Unit. AGBU has about 20 professional staff and works closely with ABRI on research, development and delivery of advanced livestock breeding technology worldwide.

The ILR software is comprehensive and flexible and has been applied successfully across a number of livestock industries, including:

- Angora goats
- Boer goats
- Dairy cattle
- Beef cattle
- Buffalo
- Red deer
- Elk
- Ostrich
- Alpacas

ABRI also markets software for genetic evaluation of pigs (world wide), it runs a web-based animal enquiry system for Australian Stock Horses and Australian Quarter Horses and distributes software worldwide to the racehorse breeding industry.

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In 2001, ABRI expects to process around 514,000 registrations on its software for over 60 breed associations worldwide. The distribution of these registrations by livestock grouping is shown in Figure 2.

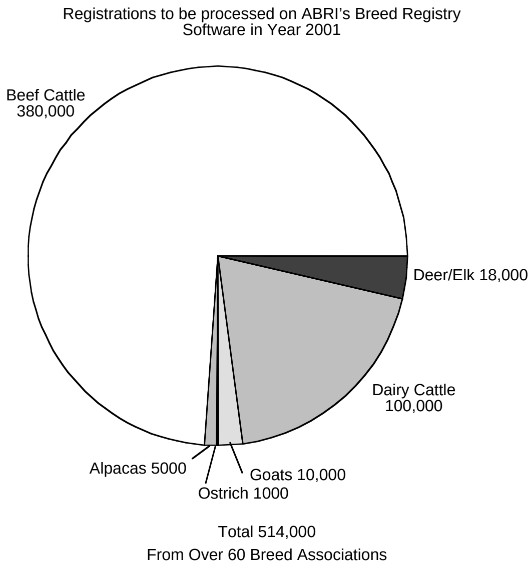

Figure 2. Breakdown showing the proportion and numbers of registrations per livestock grouping.

The International Livestock Register software engine that performs the registrations and maintains the animal database is rock solid, having performed millions of transactions on databases which now extend to **over 30 million animal records**. It combines pedigree, performance recording and an accounting interface in one integrated system. Internet functions come as an optional enhancement.

Computer Resources

ABRI owns and/or manages what is believed to be the most extensive computer network in the world for processing of livestock improvement information as detailed in Figure 3. All the equipment is sourced from the leading US manufacturer, Compaq Computer Corporation and is based on 64-bit chip Alpha workstations to achieve very fast computer speeds.

By the end of year 2001, ABRI's network will include 29 workstations and some hundreds of attached terminals and PCs. It extends over a number of countries. Our systems are supported by an in-house team of 17 software developers. By owning and controlling the breed registry software and having substantial in-house software development expertise, we can respond quickly to client demands.

International Activities

ABRI's livestock improvement technology is now used in 20 countries as below in Figure 4:

The international market for research-based livestock improvement services is very competitive. ABRI's success provides a compelling testimonial for the quality of the products it provides and its back-up services.

Market Share of Pedigree Recording in Australia

ABRI is the dominant provider of pedigree services to Australia's livestock industry as the chart (Figure 5) shows.

In addition, ABRI has captured considerable market shares in overseas livestock industries.

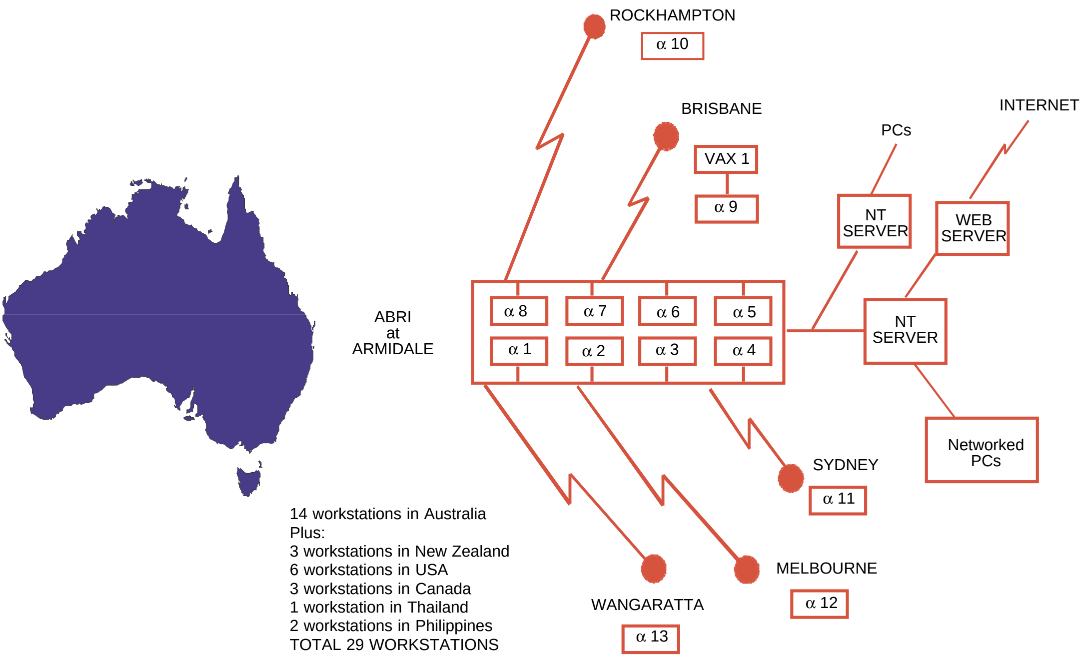

Figure 3. The alpha computer systems owned or managed by ABRI.

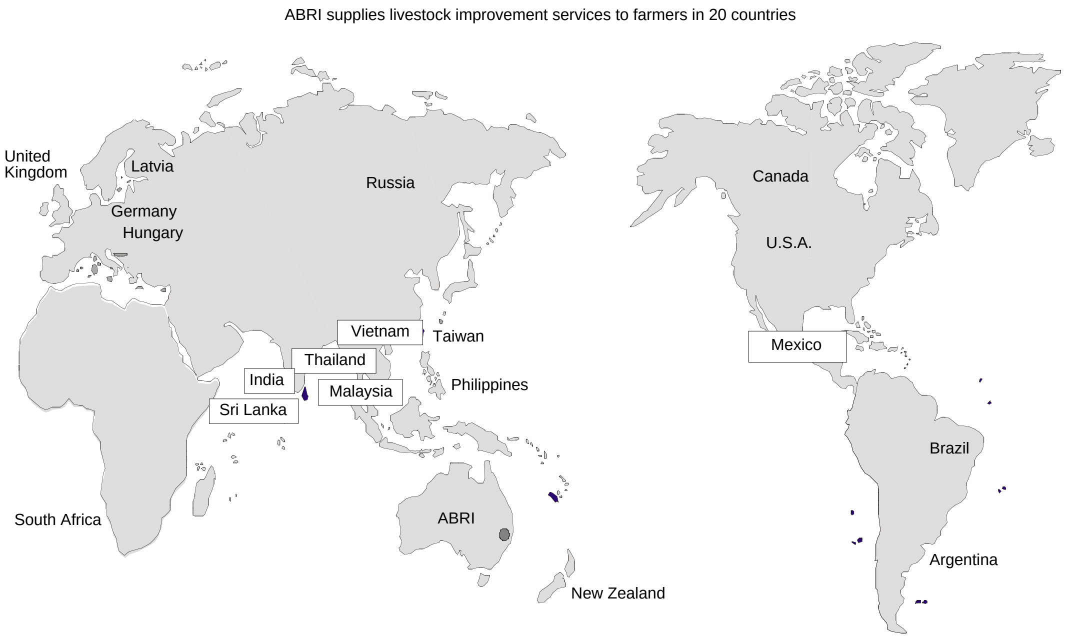

Figure 4. Map of countries that have farmers utilising ABRI's livestock improvement technology.

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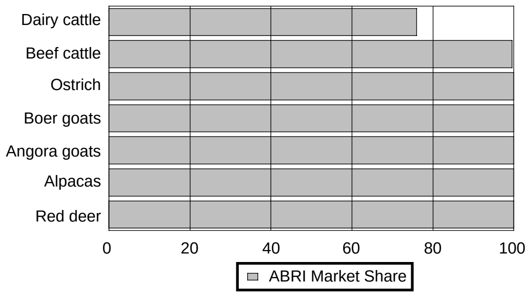

Figure 5. Estimated ABRI market share of Australian registrations by livestock industry.

Market Leader in North America

ABRI introduced its software to the North American market in 1990. ***In just 10 years, it has become the most widely used breed registry software in the North American market***. By the end of year 2000, ABRI software had installed in nine (9) computer centres in North America and servicing thirteen breed associations.

Figure 6. Map of North America showing the sites of Breed Societies running ABRI's software.

BREEDPLAN

ABRI's BREEDPLAN genetic evaluation system is arguably the most advanced of its type in the world. It is used nationally in Australia, New Zealand and Thailand and is about to be adopted as the national system in Hungary and the Philippines. Other countries to use BREEDPLAN are the USA (for ten years), Canada, Argentina, Mexico and the UK.

BREEDPLAN is currently used by a large number of beef breeds including:

Angus*
Australian Lowline
Beef Shorthorn
Belgian Blue
Belmont Red
Blonde d'Aquitaine*
Boran
Braford
Brahman
Brangus
Braunvieh
Charbray
Charolais*
Devon
Droughtmaster
Galloway
Gelbvieh
Hereford*
Limousin*
Maine Anjou
Murray Grey*
Native cattle (Thailand)
Piedmontese
Poll Hereford*
Red Angus
Red Poll
Romagnola
Salers*
Santa Gertrudis
Shaver Beefblend*
Shorthorn*
Simmental*
South Devon*
Tuli
Wagyu

* Denotes breeds that are already involved in international genetic evaluations run by ABRI.

Twelve of these breeds already pool data across two or more countries to produce international genetic evaluations.

The performance evaluations can be run for a wide range of traits including covering growth, fertility and carcass (Table 1).

Table 1. Traits that can be included in genetic evaluations.

Growth	Fertility	Carcass
Birth weight	Scrotal size	Eye muscle area
200-day milk	Days to calving	Fat thickness (rib)
200-day weight	Gestation length	Fat thickness (rump)
400-day weight	Calving ease — direct	Carcass weight
600-day weight	Calving ease — daughters	Meat yield %
Mature cow weight		Intramuscular fat

Dairy Applications

ABRI has breed registry software for the dairy industry operating in Australia, the USA and Canada. Breeds covered include Holstein-Friesian, Jersey and Ayrshire with a total of 100,000 registrations processed per year.

ABRI also operates the Dairy Express herd recording service. This is the largest such service in Australia operating in three states and involving over 200,000 cows on monthly recording. The pedigree and production data are sent electronically to the Australian Dairy Herd Improvement Scheme for the national genetic evaluation.

Internet Applications

ABRI has developed a number of Internet applications for breed association databases which have proved to be very popular. These include:

- electronic herdbook enquiry service;
- membership enquiry system;
- sale catalogue facility;
- private treaty sale facility;
- listing of AI sires;
- mating predictor (of EBVs);
- internet-based registrations.

Future applications will include an electronic system of tendering cattle for sale.

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An example of this ABRI-developed technology can be found at the American Hereford Association site:

www.hereford.org

and follow the link to 'Try out AHA's new advertising and search tools'.

By February 2001, ABRI had internet database services introduced for seventeen (17) of its corporate clients. The aggregate hits reached a staggering 271,199 in February and this statistic is on an exponential rise as more livestock industry individuals and organisations learn the value of the information that can be accessed using ABRI's software.

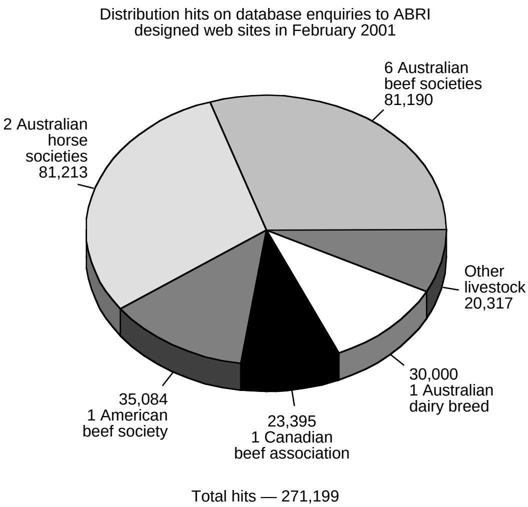

Figure 7. Measured hits to ABRI designed web sites.

Developing Country Projects

The Australian Centre for International Agricultural Research (ACIAR) has supported the development of the ILR technology in use by ABRI and AGBU livestock industries in a number of developing countries — particularly Thailand, Philippines, Vietnam and South Africa. Technology development and implementation can be combined with formal courses in animal genetics provided through the University of New England.

Further Enquiries

ABRI is a dynamic information technology company with a wide range of products, particularly in the area of livestock improvement. It is based on the campus of a prestigious University from which it sources much of its technology. In 1996, ABRI's Managing Director was ranked in the top ten achievers in Australian agriculture by the Rural Press Group. In the same year, ABRI was given the inaugural award from the Armidale Development Corporation for being the company making the greatest economic contribution to development of the Armidale region. Enquiries regarding ABRI's services should be made to:

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Noan Swang Thai Buffalo Conservation Village

Moo 10, Na Vha Subdistrict, Phy Wiang District, Khon Kaen Province, Thailand

IN 1964, the Thai Government began constructing the first large dam for use in a hydro-electricity scheme. A new village was established to house the people relocated due to the construction of the dam. The new village was called Noan Swang Village.

This village is 94 km from downtown Khon Kaen. The total area is 5000 rai (about 1000 hectares) of which 500 rai is used for housing of the 175 households, 2000 rai for cropping, and the remainder is communal land for livestock grazing.

The population consists of 530 males and 580 females (total 1110). The majority of these people work in the rice plantations and in livestock production, especially buffalo and beef cattle raising. These are traditional agricultural pursuits in the region but are a second alternative income from the fishery in the new dam.

Noan Swang is the target village for livestock development because the farmers are interested in livestock production and are willing to learn from the Government extension services. As part of this program, the livestock provincial officers will also provide grass and legume seeds for pasture development and demonstrate how to use vermicide for internal parasites and how to improve buffalo production by giving minerals to the buffalo.

There are 60 households (34%) raising 629 buffalo.

Male buffalo	163
Birth to 3 years	140
More than 3 years	23
Female buffalo	466
Buffalo cows	170
Birth to 2½ years	151
2½ years to breeding	145

Buffalo calves born alive

Sex	Year		
	1998	1999	2000
Male	42	64	(24)
Female	60	65	(32)
Total	102	129	(56)

Noan Swang buffalo conservation administration

The conservation village has established 5 committees:

1. Administrative committee for conservation and Thai buffalo development.
2. Animal drug fund committee.
3. Animal health medical care committee.
4. Buffalo raising security guard committee.
5. Buffalo marketing committee.

Accomplishments and potential of village development

1. The farmers in the village decided to borrow two buffalo bulls from the Khon Kaen livestock province for mating to improve the breeding stock.
2. Buffalo-raising is the cultural heritage from the ancestors and this village has the highest number of buffalo in the province.
3. Noan Swang village can be developed as a tourist attraction displaying the conservation model and a working buffalo village.
4. In 1995, the village mutually agreed to construct 2 large reservoirs in order to preserve clean water for buffalo consumption.
5. In 1996, in order to solve the labour problems arising from raising buffalo in the communal area, a rotation of 6–7 security guards was arranged to protect the buffalo from theft during the daytime.
6. The villagers established an animal drug administration fund to benefit from the financial support of the international organisation for Thai native buffalo development. Currently, the village has 7749 Baht (US$172).
7. The villages initiated and maintain a herdbook of animal pedigree and calving information, and attach identification ear tags to the animals.

Government collaboration

There are several types of livestock extension services:

- Internal parasite vermicide;
- Undesirable buffalo bull castration;
- Brucellosis vaccination every year since 1997;
- Use of high ranking estimated breeding value (EBV) bulls to mate with native buffalo cows;
- Making culling decisions and disposing of buffalo cost because of long calving interval or the age of the cows.

Buffalo marketing

In 1999, the villagers sold about 3 buffalo per family, totalling 141 head. This income is estimated at 1.8 million Baht (UA$40,000) or about 13,000 Baht/head of buffalo (US$288).

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Future planning

1. Construct a new building to house a display highlighting the buffalo culture and agricultural equipment, and develop it as a tourist attraction.
2. Campaign to use buffalo manure as fertiliser, without chemical fertiliser and to use buffalo as draught power for rice cultivation.
3. Encourage people to eat the whole rice (rice with bran).
4. Continue to use high-ranking EBV bulls.
5. Keep buffalo cow pedigree and production records.
6. Collect buffalo manure for sale.
7. Promote buffalo through the show ring to encourage the continuation of buffalo development.

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