FUTURE DEVELOPMENTS IN THE EXTENSIVE BEEF INDUSTRY

INTRODUCTION

B.D. SIEBERT*

The raising of beef cattle under extensive systems of management is subject to the vagaries of the environment. In northern Australia heat and humidity, along with parasites and other diseases, place a direct stress on grazing animals. Further, rainfall is often low or erratic so that droughts are not uncommon. Native pasture in much of the area has evolved in an environment of low soil fertility, under arid or seasonally dry conditions with brief periods of high rainfall. The result is a fibrous forage of low quality. Because of these limitations, productivity is low, brought about by low rates of reproduction, survival and growth. For many years the industry has been based on the use of temperate types of cattle which originated and were selected in much higher latitudes. Such animals under stressful unimproved, low management systems are not the most suitable.

Despite the environmental constraints and seasonal fluctuations however, inputs have been small, markets relatively reliable and the industry profitable. If markets become less reliable or more specific in their requirements greater demands will be placed on the producer to become more efficient.

The following papers firstly consider international market trends in the foreseeable future. The subsequent paper will consider the constraints in industry if the producer needs to change his product or rate of production. The third paper will consider what options are open to producers in economic terms in the light of these constraints. Finally, the findings of research over the last two decades will be considered in relation to how they might assist industry in selecting the type of animal or system of production most suitable for the environment.

THE INTERNATIONAL MARKET OUTLOOK

W.D.S. HARPHAM**

Many people within the beef industry seem to project an unhappy outlook for 1982. Their pessimism comes about largely because the expectations they held for improved market demand and prices last year were not achieved.

TRADITIONAL MARKETS

Australia's traditional Pacific Basin meat trade to USA, Japan and Canada declined in 1981 due to the general downturn in the economies of importing countries and higher than expected levels of domestic meat production.

Many factors have contributed to industry stress, among them:

- Our still declining cattle herd.
- The continuing need for processing plant rationalisation.
- Poor demand and prices experienced in the US market.
- Producer dissatisfaction with export cattle prices.

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- Problems of currency exchange rate fluctuation and cost inflation.
- Industrial disputation, particularly affecting the waterfront.

Undoubtedly these factors will continue to depress enthusiasm in the industry in 1982, but while there are no clear and immediate signs of general improvement, neither is there indication that conditions will deteriorate very much further.

In the USA, with domestic beef production virtually unchanged and poultry production up significantly, meat supplies have been too high for prices to be maintained at 1980 levels. Despite lower price levels, demand for beef has not improved and consumption remains low. This could simply be a reaction by consumers to the current poor economic conditions, but it could also reflect a long-term trend towards lower consumer spending on all meats and a shift in consumer preference towards poultry. Following a period of low beef consumption, consumers may have adapted their tastes to accept a diet with less beef content. These propositions will only be tested when consumer income recovers in the U.S.

The proportion of Australian exports (boneless equivalent) going to the US fell from 64% in 1980 to 55% in 1981. Domestic pork supplies can be expected to fall in 1982, whilst beef and poultry supplies should continue to increase. It is distinctly possible that Australian exports to the US will not be limited by US import restrictions over the next 4-5 years. The reason is not that access levels will be high, but that the quantity of meat available for export will remain well below the levels attained in 1979/80. Australian exports in 1981 amounted to only 245,000 tonnes - 92,000 tonnes below the access Australia could have expected if voluntary restraints had been introduced (assuming a share a 51.3%). For the next four to five years at least, unless US prices increase significantly or a severe down-turn in other markets occurs, exporters may not wish to ship quantities in excess of the access levels.

In Canada, both general economic conditions and domestic supply levels have followed the pattern in the US. The proportion of Australian exports destined for Canada has fallen from 4.6% in 1980 to 4.1% in 1981, despite the drop in total shipments overseas. No improvements in export levels can be expected in 1982. Longer term access to this market will be strongly influenced by the type of import regime finally introduced in Canada to control beef imports. Under the present proposal, Canada would guarantee a minimum access level of 63,000 tonnes. Australia's traditional share of this quantity would be about 25,000 tonnes - well in excess of expected 1981 exports of 16,000 tonnes and a level unlikely to be reached for several years.

In Japan, domestic prices have been under pressure from increased domestic supplies and low consumer demand. Nevertheless, Japan still remains one of Australia's major markets for beef, as well as mutton. In 1981 Japan accounted for 19% of Australia's beef exports and 34% of its mutton exports. Although the Japanese government is keen to protect the interest of its producers, it has also undertaken, under the Multilateral Trade Negotiations, to endeavour to increase the global beef import quota of 135,000 tonnes by Japanese Fiscal Year 1982. It is expected that imports during 1982 will not exceed the level of the previous year, but the timing and quantity of imports will largely depend on political decisions influenced by the level of producer incomes and the general state of the economy. The latest supply and demand projections allow for Japanese beef demand to increase by about 4% p.a. between 1978 and 1990, with a corresponding decline in the self-sufficiency rate from 73% to 71%. The net result should be an increas increase in imports by about 105,000 tonnes carcass weight to 255,000 tonnes.

With lower price levels in North America, other minor traditional markets have been able to compete more effectively for Australian beef exports, Countries in East Asia, in particular, increased their imports in 1981 and are expected to maintain the higher level of purchases in 1982. Prospects for any growth in meat exports to the EEC are few. Total meat exports to the EEC in 1981 were around 15,000 tonnes comprising 5,000 tonnes of beef, 7,000 mutton and the remainder of lamb. A similar amount is expected to be shipped in 1982 given that a high level of domestic meat production is expected to continue, at least in the short term.

Australian meat exports to the Middle East have grown rapidly, particularly since late 1974 when regional incomes were boosted by large increases in oil prices. Over the past five years Middle East countries have averaged around 12% per year of total Australian meat exports. Most of the countries have a traditional preference for sheepmeats and in the 12 months ended June 1981 the Middle East region accounted for 24% of mutton exports and 68% of lamb exports from Australia. Australia sold substantial quantities of beef to Egypt and Iran in 1977 and 1978 but over the last few years the EEC has been able to supply large quantities of heavily subsidised beef from intervention stocks to Egypt and Iran. The Middle East has also been an open market for exports of frozen poultry from the EEC and South America. All these factors have contributed to lower sales of Australian beef in the Middle East recently and, without a lowering in the relative prices of beef, this situation is unlikely to change.

NEW MARKETS

General economic stagnation coupled with higher levels of self-sufficiency amongst potential importers and the increased flow of EEC beef onto the world market, have reduced opportunities in new markets for Australian meat exporters over the past few years. More significant however have been the transient buying activities of less regular markets. These markets are characterised by movement in and out of the international marketplace according to price fluctuations and government directives.

South Korea, after a two year absence from the market, took nearly 7% (30,000 boneless equivalent) of Australia's total beef exports in 1981. Markets in South East Asia are generally price sensitive, however there is potential for beef imports in a number of these countries. Domestic production in Malaysia, Philippines and Taiwan is unable to keep pace with growing demand and in Singapore there is a growing demand for fast foods.

Similarly the USSR re-emerged as an important meat buyer duing 1980 with purchases amounting to 80,000 tonnes, including 77,000 tonnes of mutton. The Soviet Union remains an opportunistic buyer, generally entering the market when world prices are depressed. With increased pressure on grain and fodder supplies after another disappointing harvest this year, demand from the USSR for imported meat to supplement dwindling domestic supplies should remain comparatively strong.

Despite the lack of optimism regarding emergence of new markets for meats Australia has high hopes that Mexico will become an important trading partner over the next decade. Although Australia's meat exports to Mexico to date have been negligible, the expansion of the Mexican economy, financed largely by oil wealth, and its rapidly growing population suggests that her relatively static domestic meat production will need to be increasingly supplemented by imports.

CONSTRAINTS TO CHANGES IN BEEF PRODUCTION

R.W.L. WILSON*

The beef industry of northern Australia is comprised of herds ranging from less than 100 cattle run in conjunction with other on- or off-farm enterprises, to more than 10,000 where often there is no other interest. Control of these enterprises varies from sole trader to company control by a board of directors, while management varies from intensive in developed areas to extensive in areas further from markets and services. Such a range of control and management in a variety of locations means that the nature of the industry is diverse. Whatever the situation, any change in the industry has to be accomplished by one or all of the following means: increasing the stocking rate by land and herd development; changing the land use (e.g. cash cropping to beef); increasing the efficiency of production. There are constraints to such changes however, and they fall into the following categories:

(i) *environmental* (climate, disease, forage quality)

(ii) *developmental* (capital availability, cost/return structure)

(iii) *rate of production* (growth and reproduction rates, weight at sale)

(iv) *management* (management skills, personal ambitions)

(v) *technology* (breeding, disease irradication, supplementation, pasture improvement)

ENVIRONMENTAL

The climate of northern Australia stresses beef cattle by the direct effects of heat and humidity and the indirect effects of lack or seasonality of rainfall. These effects are summarized in Fig. 1.

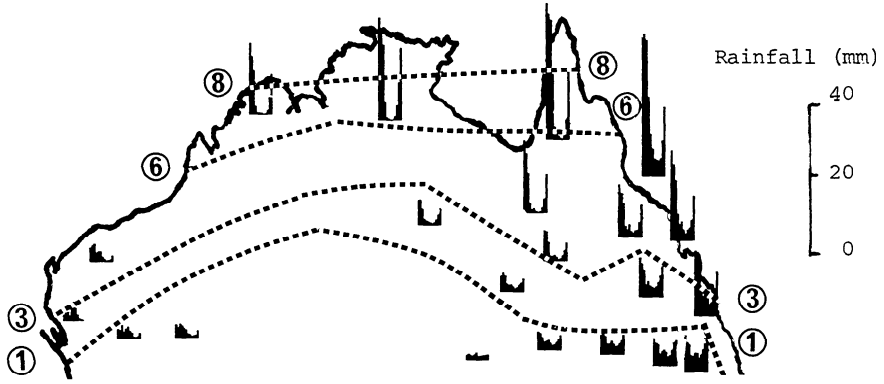

Fig. 1 The annual rainfall patterns for various areas of northern Australia showing monthly aggregates together with the isotherms of the number of months (e.g. ③) during which the average wet-bulb temperature exceeds 21°C.

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The number of months that livestock must tolerate temperatures in excess of 21°C wet-bulb increases in a northerly direction. In arid areas with low humidity (< 25% relative humidity (r.h.)) this results from high daily dry-bulb temperatures (> 35°C), whereas in the humid tropics (> 40% r.h.) it occurs with moderate to high temperatures (> 25°C). As a result animals possessing a high degree of heat tolerance are required in humid northern Australia. Rainfall is mainly in summer with dry season from May to October-December. Minor droughts of less than six months, causing severe depression in animal performance, can be expected each three-four years and major droughts with more than six months' severe depression in animal performance each seven-eight years (Alexander 1966). Drought conditions result in increased mortalities, especially in breeding cows and calves and weaners, and reduced weight at slaughter or increased age at slaughter. Besides the direct losses, indirect losses through reduced cull cow sales and reduced calving during and following the drought year continue to be felt for up to four years. Infectious disease and parasites are other environmental stresses which reduce cattle productivity. The ecology of some parasites such as the cattle tick is largely dependent on the prevailing climatic conditions. Cattle growth is also limited by forage quality which is primarily controlled by soil fertility and climate. Table 1 shows how heat, cattle tick and forage quality limit the growth of cattle.

TABLE 1 Monthly liveweight depression caused by various environmental stresses (kg live weight/unit stress)

Heat*	Parasite**	Forage Quality***
0.75	0.60	1.30

* per °C rise in rectal temperature
** per 10 mature ticks
(Frisch and Vercoe 1982)
*** per unit decrease in digestibility (Romero and Siebert 1980)

DEVELOPMENTAL

Beef production is capital intensive and there is a delay of at least one year, and probably four or more years, before development projects start to yield returns. Producers can invest in development only when prices are sufficiently high to provide a surplus of funds to invest and/or repay loan money. Also, because of delays there needs to be confidence in future prices if development is to be undertaken. Land tenure also needs to be considered and each situation should be assessed for limitations.

Property improvement and sub-division

Development by pasture improvement through timber control and introduction of new plant species and by sub-division and installation of watering points to control grazing pressure is technically possible over large areas of northern Australia. Usually pasture improvement provides an initial period of high production followed by a period of reduced production unless the pastures are managed properly, both in terms of grazing pressure and perhaps periodic inputs of plant nutrients (T.H. Rudder, pers. comm.).

While pasture improvement programmes are economically viable, implementation depends on surplus funds. Government can and does influence land development through taxation concessions. However, unless prices are sufficiently high, maintenance and development programmes are not carried out and productivity

consequently declines. This was evident after the 1974-78 recession in many areas of Queensland.

Change in land use

The response to price changes has been demonstrated over the past three decades. Prior to 1974 prices showed a relatively constant upward trend and production of the national herd rose to record heights. After that, prices were low for about four years, then they fluctuated widely for the next three. Subsequently, beef production and production potential in Australia fell to comparatively low levels (Jenkins 1981). The decline in production was not marked in Queensland and Northern Territory but there was indication of reduced production potential.

The decline in productivity was greatest where there was on-farm alternatives e.g. grain, sheep, and comparatively slight where alternatives were largely limited to off-farm investment. In northern Australia the potential for on-farm diversification is greatest in a band of approximately 300 km from the coast and extending from the Queensland/New South Wales border to Mackay. This region carries about 45% of the 12 to 13 million beef cattle in northern Australia. It seems possible to expect that output in this area will contract and expand according to the relativity between grain and beef prices. At the present time contraction of output is occurring and could be expected to continue.

RATE OF PRODUCTION

The majority of producers in northern Australia breed and sell either store cattle at 1½ to 2½ years of age or breed and fatten steers at 2½ to 4½ years of age. This means that there is a planning horizon of from 2½ to 5½ years before output can be markedly increased through increased numbers. Thus any increase by improving reproductive rates or by mating additional animals is substantially delayed. While it is technically feasible to improve reproductive rates, historically output has been raised mainly by increasing breeder numbers. This is preceded by a decline in output because sales of cull females are deferred until numbers reach the desired level.

Reduction in age at sale through use of tropically adapted cattle and/or through improved pasture or crop usage is also slow. In the case of changing to tropically adapted cattle it takes four to five years before production increases start and eight to ten years before a new equilibrium level is reached. Improvement through nutrition takes at least two years before an increase in production is noticed, and six to eight years before it reaches equilibrium. The reason for these delays is that as age at sale is reduced breeder numbers and/or reproductive rates have to increase to maintain the stocking pressure (Rayner 1968).

Increasing weight at sale from 560 to 640 kg live weight for steers and from 400 to 480 kg live weight for cull females offers the least number of constraints in terms of time lag and investment. At the weights suggested average carcass weightswould be about 270 kg for a breeding and fattening herd output. Currently, average carcass weight in northern Australia is 200-230 kg (Anon 1975).

MANAGEMENT

Productivity of a beef herd is influenced by many managerial factors and any potential change in beef production will need to be matched by the skills of management. Some factors which are of importance include:

(i) Stocking rate control

(ii) Servicing of equipment
(iii) Selling strategies
(iv) Budgetary control

Efficient management depends on the availability of a skilled workforce as well as access to materials required to keep equipment serviced. It is often difficult to attract and maintain skilled labour for station work, many beef properties being isolated areas where there are problems concerned with education and social facilities. While the problem exists and undoubtedly reduces output, the solution is not easy. Owing to distance from suppliers of materials and often local shortages, development and maintenance work can be delayed. This type of delay varies from small items which have little effect to major land development programmes.

All these matters are constraints on present production and most will continue in the future. Managerial skills must be developed so that foward planning and better man management minimize these constraints.

TECHNOLOGY

Traditionally the beef industry has been slow to adopt new technology. During the 20 years prior to 1974 prices kept approximately in line with costs, but since then the cost price squeeze has become more severe. It follows that adoption of technology designed to improve productivity and reduce costs of production has become important. Managers must develop an objective approach to evaluating research results and adapting these results to improve efficiency of production.

There is a reservoir of unused technology suitable for many producers in the eastern areas of northern Australia where intensive and semi-intensive production systems are used. In more extensive areas there may be a need to refine or prove such practices (e.g. controlled mating, strategic weaning) and this lack of proven technology may be a constraint for some time to come.

ECONOMIC OPTIONS TO CONTEND WITH FUTURE TRENDS

R. BEASLEY* and G.R. DAVIES**

THE ECONOMIC ENVIRONMENT

Perusal of cattle prices for the years 1960–81 (Fig. 1) (Anon 1978; Campbell 1981a) shows a volatile and less profitable market after 1973. The price of cattle fluctuated over a wide range. There is no reason to believe that the market will stabilize in the foreseeable future (Bain and Longmire 1980). While beef cattle numbers and meat marketing remain unregulated and restrictions are placed on overseas markets, wide price fluctuations are likely to be a continuing feature of the industry. Producers are faced with short periods of high profitability followed by varying periods of low or negative income.

This economic environment means that investment capital will be available during intermittent periods. To reduce the consequences of low or negative income careful planning of property investment will become increasingly important.

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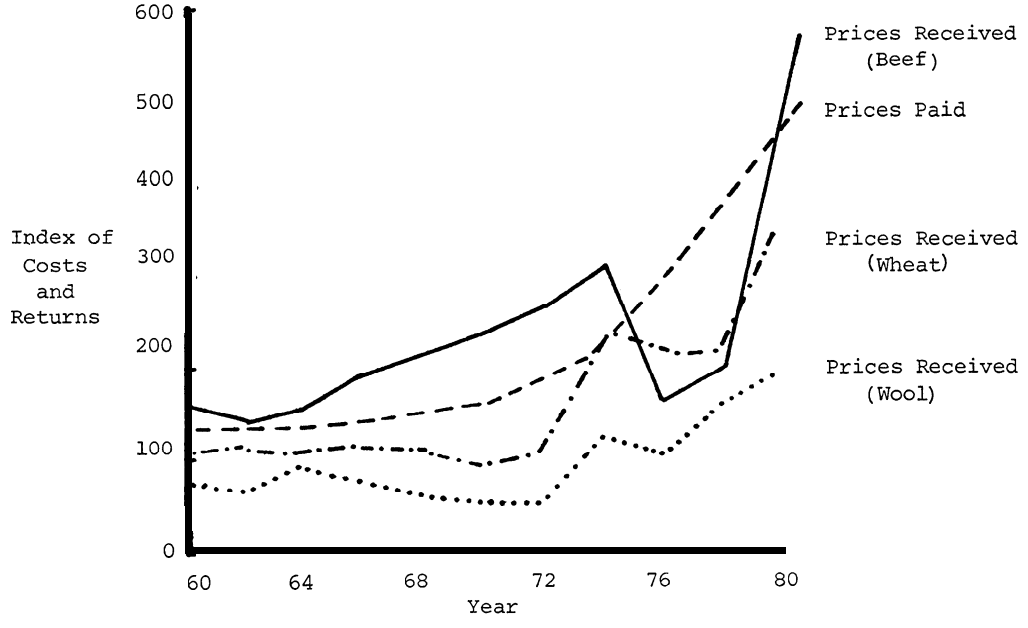

Fig. 2 Index of farm costs and prices received between 1960 and 1980
(Base of 100 = average of 1949-1959)

ECONOMIES OF SCALE

Considerable economies of scale are possible in the beef industry. cost of production estimates show production costs per head decrease as herd size is increased from 500 head to 4,000 head. Further, the degree of cost benefit increases with beef price, the estimated cash deficit being similar in central Queensland for herds from 500 to 4,000 head at beef prices of about 25¢/kg live weight, but at 70¢/kg the estimated cash surplus of $200,000 for a 4,000 head herd being about 10 times that of a 1,000 head herd. The reduction in costs per head is due to the high proportion of fixed costs relative to total costs.

Aggregation of property

Increased output can be achieved by the purchase of additional land or more intensive or efficient use of existing land. One of the major limitations of the former option is the availability of suitable land within close proximity. As an aggregation of property expands, the managerial skills of the operator become more critical, as does his ability to employ and utilize skilled managers.

Where holdings in an aggregation are geographically diverse, each holding must be a viable unit in terms of labour and management to achieve maximum economies. For this reason, capital requirements for property purchase are generally large. In most cases, due to the inherently low rate of return in the industry, internal funds are not readily available. Availability, cost and term of borrowed capital then become the key to investment decisions for property

purchase. Many beef producers tend to expand their operation rather than look at alternate investment because of their intimate knowledge of their industry and lack of knowledge of alternative enterprises.

Intensification of production

Economies of scale can also be achieved by intensification of production techniques. This can be by property development or more efficient management. Property development, in general, requires less capital than property purchase and expenditure can be spread over a protracted period. Individual development programmes can show a very high rate of return on capital but care must be taken that each development segment co-ordinates to achieve an overall improvement in economies. The degree to which this approach can be exploited depends on increased capacity and technological innovations.

There is a time lag frequently four or more years from the commencement of a development programme until some economic return is achieved. The net economic return is frequently reduced due to need for maintenance of the development, loan repayments and taxation.

Intensification of an operation can be achieved also by production of stud cattle or by intensive feeding, e.g. irrigation, feedlotting. Under certain circumstances these practices may result in greater income from a given area, but generally the more intensive the operation, the more vulnerable the operation is to fluctuations in beef prices and costs of production.

COST ECONOMIES IN PROPERTY MANAGEMENT

Compared with economies of scale, cost economies are generally small, but they require relatively low capital outlay and are worthy of attention.

Labour

Labour costs per unit of production fall as the size of the enterprise increases. The cost of labour is around 50% of total costs on a property running 500 head, decreasing to around 25% on a 4,000 head property. On most extensive beef properties, labour is the largest single cost. Therefore the most usual cost economy is the replacement of labour by capital expenditure. However, some capital expenditure makes working conditions easier or more pleasant e.g. housing, yards. It has no direct productive capacity but may have intangible benefit through attracting and retaining skilled labour.

More labour than is justified on a permanent basis is often employed to cater for peak periods of demand. Options available to reduce permanent labour requirements include the use of casual labour, labour sharing and better planning of operations and timing of operations.

Financial control

Financial planning and control is one area which is often overlooked. Borrowing can be reduced by timing capital requirements and purchases to cash flows. It is often advisable to borrow from a number of sources depending on the amount and term of money required. Use of leasing arrangements can allow available capital to be used for other purposes. Finance for specific purposes may be available at longer term and concessional interest rates from Government sources. Cash which is not required immediately can be invested short term to a return until required.

Marketing policy

The approach taken to cattle marketing can have a major effect on profitability. The type of cattle produced, the weight and age at sale, the method and timing of marketing can affect income levels.

Careful use of beef futures can result in more stable prices in the short term. Where commitment to financial institutions is a high proportion of income, futures can be a useful management tool. In the longer term, possible changes to the marketing system by the use of carcass classification for sale by specification would allow production of specific types of cattle for particular markets with resultant improvement in efficiency.

DIVERSIFICATION

Diversification offers producers better chances of surviving a period of low beef prices in a better financial position. This approach can take many forms but can be basically categorized as on-farm and off-farm diversification.

On-farm diversification

There are a number of requirements for on-farm diversification to be successful. There must be a suitable alternative industry available with sufficient economic return and prospects to make a change advisable. Additionally, the property must be suitable and capital available for the new enterprise.

Areas of western Queensland can carry sheep or cattle and coastal and sub-coastal areas of Queensland have a number of alternative enterprises. The balance of the area does not have the natural resources, technology or infrastructure to exploit diversification. The major diversification has been into coarse grain and oilseed production. Where suitable soils and rainfall have been available, this has been an obvious and, to date, profitable diversification.

The production of summer grains and beef are compatible in terms of labour requirements. A combination can result in a full utilization of property labour throughout the year. Additionally sorghum stubble or failed crops can be used to advantage to fatten cattle during a period when it is often difficult to produce fat cattle and premium prices are usually available.

Off-farm diversification

Off-farm diversification has become a much more popular form of investment during the last decade. This form of investment may have the advantage of relatively good rates of return and certainty compared to beef production. Additionally investment can be in any amount from relatively small amounts to very large projects. Compared to holding reserves in the form of cash, investment in real estate, debentures, premium stocks and shares will generally show a much better return. These assets are readily saleable when liquidity is needed for alternative business transactions. The major disadvantage is that selection of good off-farm investment requires a good knowledge and understanding of the enterprise or industry and often close supervision.

Therelative rates of return between on-farm and off-farm investment are difficult to compare due to the influence of capital gain. Campbell (1981b) estimates the rate of return from beef properties for the four years to 1981 at an average of -0.6% but after allowance for capital gain, this rate increases to an average of 12.2%. Rates of return including capital gain are of only academic interest to a producer who does not wish to sell the property.

Another source of non-farm income has been from owners working off-farm. For producers with small herds, this became essential during the period of low prices. It would appear that cost pressures and technology to combat these pressures will continue in the industry and larger herds will be required per management unit. Small property units will be unable to generate sufficient funds to purchase more area or be able to meet commitments on borrowed capital.

RESEARCH FINDINGS IN RELATION TO FUTURE NEEDS

B.D. SIEBERT

In future, beef production from extensively managed properties in Australia will need to be more flexible to meet variations in the market, yet at times more specialized to meet stringent requirements of overseas markets. This means that there will need to be an increase in the efficiency of production as well as an improvement in the quality of the product. To achieve these aims, producers will need to use animals that can withstand the environmental stresses associated with extensive animal production and at times use more intensive methods to increase the rate of production.

Rate of production in the tropics is constrained by the environmental stresses of heat, disease and forage quality or availability, all of which limit growth and reproduction rates. Such constraints can now be overcome by including the introduction of new cattle types on the one hand and the use of new pasture species or nutrients on the other.

CATTLE TYPE

Although the production of all breeds of cattle studied to date is depressed by a rise in body temperature or parasite load, tropically adapted genotypes are resistant to the stress per se. Such animals have lower rectal temperatures and tick counts than temperate breeds at the same level of exposure to the stress (Table 2). This is not always true for gastrointestinal helminths where there is evidence for tolerance to worms in adapted breeds, that is, different breeds may carry similar burdens but adapted breeds respond less to helminth treatment (Seifert 1971, Turner and Short 1972).

TABLE 2 Breed responses to heat and parasites

Genotype	Free of heat and parasites (indoor) R.T. (°C)	Free of parasites - exposed to heat (grazing) R.T. (°C)	Exposed to heat and parasites (grazing)		
			R.T. (°C)	Tick count	Worm egg count (epg)
Tropical	38.2	39.8	39.6	2	197
Crossbred	38.3	39.8	39.6	18	356
Temperate	38.2	40.5	40.4	44	204

Under these conditions, temperate animals had higher rectal temperatures and carried more ticks than tropical animals because they were less adapted to the environment. After many years of raising mainly British breeds of cattle, cross-breeding with Brahman and Africander breeds has increased markedly the number and proportion of tropically adapted animals in northern Australia over the last 15 years. In Queensland, for instance, there were only 12% tropically adapted animals in 1965, but by 1980 this had risen to about 75%.

GROWTH RATE OF ANIMALS

Heat and parasitic diseases both affect the rate of growth of cattle directly and also indirectly by reducing feed intake, but different breeds are affected differently. Table 3 shows the growth rate of three cattle types, firstly free of stress, secondly exposed to heat but not to parasites, and thirdly exposed to both heat and parasites.

TABLE 3 Liveweight gain (kg/day) of three cattle genotypes exposed to, or free from stress (Frisch and Vercoe 1982)

Genotype	Free of heat and parasites	Free of parasites	Exposed to heat and parasites
Tropical	0.68	0.61	0.61
Crossbred	0.75	0.69	0.59
Temperate	0.81	0.61	0.38

It is apparent that in the absence of heat and parasitic stresses, the temperate breed-type grows most rapidly, that is they have the highest growth potential. At intermediate levels of stress the crossbred is sufficiently well adapted to express its intermediate level of growth potential and it then has the highest gain. At high levels of stress the tropical breed-type is the only breed sufficiently well adapted and its realized growth rate is the highest despite the fact that its growth potential is the lowest. The level of adaptation required for maximum growth rate in a particular environment depends entirely on the level of stress that the environment imposes. It is evident that across breeds growth potential and resistance to stress are negatively correlated. Why this should be so is not clear; certainly natural selection, which operates for survival, or artificial selection operating for improved growth rate, will always be for a combination of growth potential and resistance to stress appropriate to the environment in which the selection is occurring. The research at the Tropical Cattle Research Centre is looking at ways of maximizing the levels of both growth potential and resistance to stress. If this is possible such a breed-type should perform well relative to other breeds in all environments.

When breeds are kept free of heat and parasites, temperate animals consume more feed per unit live weight than tropical animals. Table 4 shows that this difference is maintained over a range of feed quality until at very low quality diets a situation is reached where tropical and temperate breeds both eat very small amounts, possibly at a point where nutrient deficiencies cause a failure of rumen function (R.A. Hunter, unpublished data).

TABLE 4 Voluntary feed consumption per unit live weight (g/kg/day)

Breed	Diet Quality		
	High	Medium	Poor
Hereford	36.0	18.0	12.9
Brahman	27.5	16.5	12.6

Allowed to express these differences in feed consumption, temperate animals outgrow tropical animals on abundant high quality diets, but if feed consumption is limited, the lesser energy requirement of tropical animals allows them to gain

more or less weight (Frisch and Vercoe 1977). This is further demonstrated when diet quality declines. Table 5 shows the difference in liveweight change between breeds fed fixed amount of forages of declining digestibility (B.D. Siebert, unpublished data).

TABLE 5 Liveweight change (kg/day) of two breeds of cattle fed five different forages

Breed	Digestibility (g/g)				
	0.67	0.62	0.56	0.54	0.50
Hereford	0.25	0.21	0.11	0.08	-0.04
Brahman	0.32	0.27	0.21	0.16	0

IMPROVED NUTRITION

To achieve greater growth rates in cattle in the tropics, it is necessary to increase the input of nutrients by pasture improvement or supplements. Since the quality and availability of extensive pastures differ in different climatic zones, strategies will differ. In the humid tropics, the period of vegetative growth is short relative to that of temperate areas, and there are many months during which animals must maintain themselves on forage of poor quality. In the arid zone pasture availability is low but the quality is better and there are few parasite problems (Table 6).

TABLE 6 Characteristics of dry season native pastures

Characteristic	Arid Zone	Humid Zone
Nitrogen concentration (g/kg)	9.0 - 15.0	5.0 - 9.0
Cell wall concentration (g/kg)	650 - 750	700 - 900
Yield (kg/ha)	$\leq$ 2,000	$\leq$ 25,000

It is not likely that economics will permit the yield of arid zone pastures to be increased, however legume introduction into the humid zone can increase both yield and the consumption of forage. Improvement of this nature is not likely to be widespread but it might be very important in some areas. Similarly, protein supplements are able to achieve increases in consumption. Table 7 shows the effects of various approaches (derived from Hunter and Siebert 1980).

TABLE 7 Increase in nutrient intake achieved by the addition of supplements to native pastures (NP)

Forage and Improvement	Dry matter intake		Digestible energy intake
	kg/day	% increase	% increase
NP	2.79		
NP + NPN* + NPS**	3.43	23	23
NP + protein concentrate	3.84	38	54
NP + legume	4.24	52	70

* non-protein nitrogen; ** non-protein sulphur.

The quantity of protein concentrate fed was that considered minimal to overcome failure in rumen function; if fed in larger amounts or if energy concentrates such as cereals are used, intake can be increased many fold. Thus, legume or concentrate supplements can turn a poor quality pasture into one of medium quality. At lesser cost, supplements of non-protein nitrogen and non-protein sulphur can change an inadequate pasture into one that is useful expecially in terms of survival.

REPRODUCTION

The reproductive rate of some cattle genotypes in the tropics is low and like growth rate is less than that of temperature cattle in their native environment. In the tropics heat stress lowers the reproductive rate of British breeds of cattle. Table 8 shows the measured calving rate and its depression due to heat in four cattle genotypes, two tropical crossbreds and two of temperate origin, one of which has been selected for weight gain in the presence of stress and the other is random bred (Turner 1981).

TABLE 8 Calving rate of various cattle genotypes

Genotypes	Calving rate			
	Predicted (%) (at 38.5°C)		Thermal depression (%) herd mean	
	Non-lactating	Lactating	Non-lactating	Lactating
Hereford x Shorthorn (selected)	62.3	66.6	14.6	21.2
Hereford x Shorthorn (random)	64.9	62.9	17.1	25.7
Africander cross	89.5	58.3	10.6	10.9
Brahman cross	72.3	41.3	11.7	9.8

The calving rate of non-lactating Hereford x Shorthorn at normal body temperature is lower than that of the tropical crossbreds, and lower than would normally be recorded for the same genotypes in temperate environments. The calving rate of lactating Hereford x Shorthorn is similar to that of the non-lactating, whereas that of lactating crossbreds falls away markedly. A major reason for this is the cessation of oestrus following calving. Table 9 partitions the reasons for reproductive failure of lactating cows in the CSIRO herd at Rockhampton during 1979 (Post 1981).

TABLE 9 Reproductive losses in lactating cows

Breed	Anoestrus (110 days) %	Fertilization failure %	Mortality post mating %	Net fertility (live calves) %
Africander cross	10	12	10	68
Brahman cross	22	14	6	58
Hereford x Shorthorn (selected)	7	18	20	55
Hereford x Shorthorn (random)	0	19	14	67

The above results assessed by progesterone measurement show that tropical cattle, particularly the Brahman cross, are more prone to anoestrus, whereas the temperate Hereford x Shorthorn are more prone to fertilization failure, possibly indicating heat stress and mortality. Annual differences arise partly because of nutritional variation and partly because of nutrition is the level of stress. Increased nutrient input by pasture improvement has a marked effect on reproductive rate, largely by increasing cycling activity within a herd, as shown in Table 10 (Post 1981).

TABLE 10 Effect of level of nutrition on cyclic activity of 96 Africander cows

Level of nutrition		Pasture and stocking		% cycling (start of mating)
1	Low	Native pasture (NP)	(0.17 beasts/ha)	0
2	↓	NP + part improvement	(0.34 beasts/ha)	18
3	↓	Improved	(0.7 beasts/ha)	37
4	High	Improved	(0.5 beasts/ha)	47

ANIMALS FOR THE FUTURE

What animal and agro-animal research has found over the last 20 years and what these findings indicate for the future can be summarized as follows:

(i) Cattle of temperate origins have a greater growth and reproductive potential than tropical cattle.

(ii) Although both types of cattle are similarly affected per unit of stress, tropical animals are more adapted to environments with high heat and parasite burdens because of resistance to stress.

(iii) If growth potential and adaptation are not negatively correlated perfectly, it may be possible to select genotypes which have the growth potential of temperate animals and the adaptation of tropical animals.

(iv) If these traits cannot be separated, genotypes bearing a high proportion of tropical genes will be needed in cattle grazing hot, humid areas, whereas in areas of improved nutrition genotypes bearing a higher porportion of temperate genes will be able to be used, if heat and parasites are not too severe.

(v) An alternative may be to seek temperate cross animals which have a degree of parasite immunity or can be immunized.

(vi) The growth rate of tropical genotypes is not as great as that of more temperate genotypes, but will be greater than that found in animals in the past.

(vii) Similarly, the reproductive rate of tropical genotypes is also lower than temperate animals, but is probably sufficient to match the replacements needed within a herd.

Research has enabled definition of the manner in which environmental stress affects cattle and how the properties of growth or adaptation are inherited. It has shown that the properties of higher growth and reproduction are desirable, but unless conditions are suitable, animals containing a high proportion of such

genes will fair worse than their counterparts of lower potential. Where pasture improvement or greater inputs of nutrients are possible, the rate of production will be able to be increased. In other circumstances, the rate will be less, but inputs will not need to be so great.

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