ADAPTIVE AND PRODUCTIVE FEATURES OF CATTLE GROWTH IN THE TROPICS: THEIR RELEVANCE TO BUFFALO PRODUCTION[1]

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In the first part of this paper two experiments are described in which cattle of different breeds or different lines of the same breed are subjected to varying levels of environmental stress. In the first trial three breeds with differing genetic growth potential were kept et three different levels of stress. It was shown that at the lowest level of stress the breed with highest genetic potential gained most, whereas at the highest level of stress the breed with lowest potential gained most. In the second experiment this Genotype X Environment Interaction was studded further by using a Control line and a Selected line of the same breed. The Selected line had been selected for growth rate under moderate to high levels of environmental stress. Both lines were subjected to the same poor environmental conditions and growth rate and stress parameters were measured. Gains were faster for the Selected line and the mean values for each stress parameter (rectal temperature, bovine infectious keratoconjunctivitis and helminth worm eggs), were lower for the Selected line. Thus in part the level of adaptation to the environment determines by how much potential growth rate is realised under field conditions. Unfortunately because of antagonisms which appear to occur between some components of adaptation and production potential, it may not be possible to create an animal which has both high production potential coupled with a high level of adaptation.

In the second part of the work the domestic buffalo (Bubalus bubalis) is cited as an animal with moderate growth potential but high adaptation to high stress conditions. Methods of increasing overall productivity of the buffalo by improving tolerances to the environmental stresses of heat, parasites and diseases are considered. m e relationship between environmental and genetic factors in determining milk yield, fertility, growth rate and survival rate are discussed.

Key words: Cattle, buffalo, growth rate, adaptability, envirnomental stress

It is generally accepted that growth rate is one of the major determinants of productivity in cattle and consequently the literature abounds in growth rate trials. Usually it is growth rate itself which is measured and one might then be forced to the conclusion that irrespective of conditions, growth rate is always the expression of the same characters. Whilst this may be true for growth rate measured under conditions which were very favourable for growth, it is almost certainly not true under most tropical conditions.

Consider the following growth rate of three breeds of cattle which were com pared at the National Cattle Breeding Station, "Belmont" Queensland; (Table 1). The breeds were Brahman (B), F4 generation Hereford x Shorthorn (HS) and the F4 generation of the cross between these two breeds (B x HS). The growth rates were post weaning gains of steers recorded over 100 days at three different levels of stress. Under low

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stress conditions, all the animals were fed lucerne chaff ad libitum in shaded pens, kept free of ecto- and endoparasites, and diseases, particularly bovine infectious keratoconjunctivitis (BIK), were kept to a minimum. At the high level of stress the animals were under paddock grazing conditions without any control of ecto-parasites (mainly cattle tick - Boophilus microplus) or endo-parasites (mainly gastrointestinal helminth species Haemonchus, Oesophagostomum Trichostrongylus and Cooperia), no alleviation of heat stress, no treatment for BIK or any disease not previously vaccinated against and subjected to seasonal fluctuations in both the quality and quantity of available feed. At the medium level the breeds were again compared under grazing conditions but environmental stresses were lower than at the high level.

The breed with the highest growth rate differed from one level of stress to the other with gain/day highest for the HS, B x HS and Brahmans at the low medium and high levels of stress respectively, It has been reported previously that the reason for such interactions in gain/day between breeds and the level of environmental stress is due to breed differences in the underlying physiological traits which ultimately determine growth rate (Frisch and Vercoe 1978). The significance and effect on growth rate of some of these underlying traits can be demonstrated by use of Table 2.

Two lines of HS cattle, a Selected Line and a Control Line were compared under low stress conditions in pens and medium stress levels at grazing. The Selected Line was derived from the Control Line and had been selected principally for growth rate in the presence of moderate to high levels of environmental stress. In pens, differences in efficiency of feed conversion measured by the ratio of intake/gain were very small and gains were largely a reflection of the inherent appetite of each Line - the Control Line ate more and consequently gained more. The reason for the higher inherent appetite and consequent higher growth potential lies in the higher metabolic rate (measured here as fasting metabolism - FM/kg) of the Control Line. Fasting metabolism was almost perfectly related to appetite as the ratio of the two variables was quite similar for each Line. This has also been shown for other breeds (Frisch and Vercoe 1977). However, although the higher metabolic rate of the Control Line was an advantage on ad libitum feeding, it was a disadvantage on restricted feeding - the Control Line could only maintain 198 kg compared to 217 kg maintained by the Selected Line, Thus, higher growth potential is associated with a high weight loss during periods of restricted feed. This has been demonstrated previously and appears to be of general validity (Frisch and Vercoe 1977).

Table 1:
Post weaning gains of three cattle breeds at three different levels of stress (Frisch and Vercoe., unpublished)

	Brahman (B)	B x HS	Hereford Shorthorn (HS)
Level of stress		---------- kg/day ----------	
Low	.75	.81	.84
Medium	.29	.37	.27
High	.25	.21	.11

Table 2:
Traits which determine live weight gain under confinement or grazing conditions (Frisch 1979)

	Confinement			Grazing	
	Control	Selected		Control	Selected[1]
Gain in weight, kg/d	0.85	.79	Gain in weight, kg/d	.15	.25
DM intake, kg/d	5.01	4.67	Rectal temp.	40.0	39.5
Gain/intake	.170	.169	BIK[2]	5.8	4.2
Fasting metabolism (FM), Kj/kgCW/d	89.1	83.3	EPG[3]	54	15
Intake /FM	.056	.056			
Liveweight maintained on 5 kg/d of feed	198	217			

1See text for explanation
2Bovine infections Keratoconjunctivitis
3Worm eggs/g

Consider now the situation under grazing conditions when the Lines were exposed to all the environmental stresses mentioned under Table 1, except that cattle ticks were controlled. Under these more stressful conditions, gains were faster for the Selected Line. They grew faster, not because their growth potential was higher, but because their level of adaptation to each of the environmental stresses was higher. Each stress had a significant negative effect on gain/day. The regression on total gain (kg) over the period wee - 0.216, -0.033 and -0.209 for rectal temperature, BIK score (from 1 to 6 related to increasing severity of infection in each eye; Frisch 1975).and helmenth worm eggs (expressed as eggs/g of faeces -EPG) respectively. Since the mean values for each stress were lower for the Selected Line, their effect on gain was lower and in consequence, the Selected Line had higher gains.

Thus, although the maximum rate at which an animal nay grow is determined by its growth potential, it is its level of adaptation or resistance to environmental stresses, which determines how much of the potential growth is actually achieved under field conditions. It is because of differences between breeds or animals in their growth potential and level of adaptation that genotype x Environment interactions occur (Frisch and Vercoe 1978). Differences in these two broad characters, growth potential and level of adaptation, also have an important bearing on the outcome of any attempt to improve growth rate by selection for growth rate itself. If such selection is performed under low stress conditions, it is mainly growth potential that is being selected. Thus, at the low level of stress in Table 1, the HS animals would be selected, and in Table 2 the Control Line animals would be selected. However, if the level of stress is high, it is improvements in growth rate related to adaptation which is under selection, Thus, at the high level of stress in Table 1, the Brahman animals would be selected and in table 2, the Selected Line animals would be selected, Entirely different types of animals would be favoured by selection at the two extremes of stress. Where selection is imposed under conditions of stress which fluctuate between low and high (as happens frequently between seasons, years and locations) growth potential and level of adaptation will be alternately favoured. Under these fluctuating conditions any long term improvements in growth rate are likely to be low.

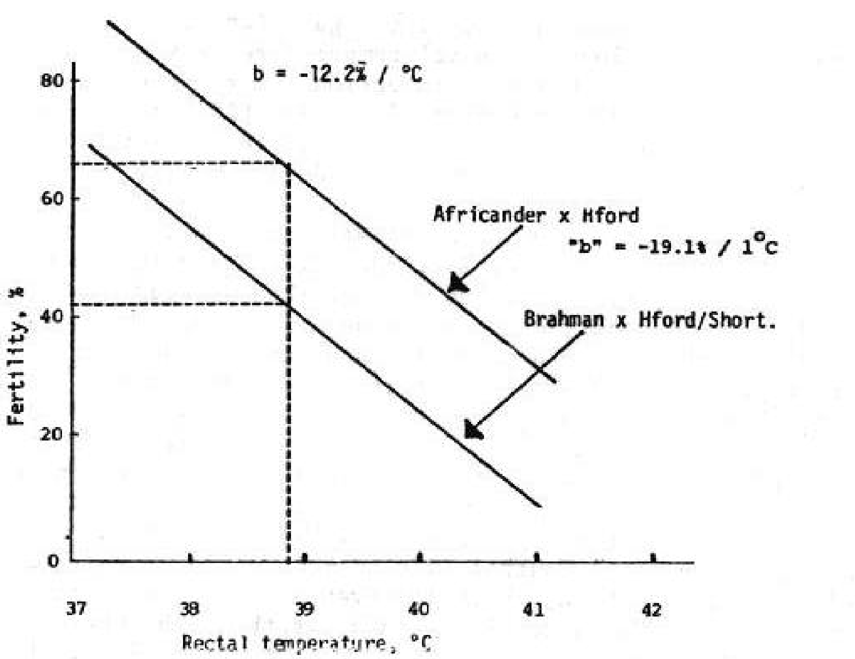
It should also be noted in each Table that the better adapted animals (i.e., the Brahmans in Table 1 and the Selected Line in Table 2), were less sensitive to fluctuations in the level of stress. They did not suffer as great a reduction in gain when stress was high but neither did they gain as much when stress was low, They were better buffered against changes in the level of stress. However, in each case, all breeds responded to improvements in conditions or all suffered some depression of growth when stress was high. None of the breeds was perfectly adapted and all could be improved.

The animal which is the "best" under all conditions is one which has a high level of adaptation combined with a high growth potential. Because of antagonisms which appear to exist between at least some of the components of adaptation and production it may not be possible to develop such an animal.

In the above examples, growth rate of particular breeds and Lines has been used as the component of production and particular parasites and diseases have been used as environmental stresses. However, the principles appear to apply equally well to other breeds or species, to the other major components of production (fertility and mortality rates) and to other more generalised environmental stresses. For example, Figure 1 shows that two breeds (A x HS Africander x HS) and B x HS- differ in inherent fertility; and in both breeds the expression of high fertility is dependent on the level of heat tolerance. Similar relationships have been shown for other adaptive components.

Where then does the domestic buffalo (Bubalus bubalis) fit in the generalised model of determinants of production?

Figure 1:
Differences between two tropically adapted cattle breeds in inherent fertility and the dependence of its expression on heat tolerance (Turner unpublished data)



SOURCE : Turner, unpublished data.

Table 3 shows data for swamp buffalo, HS and Bali cattle (Bos Banteng) compared under low stress conditions in pens. The buffalo had a comparatively low appetite (I) and fasting metabolism (EM) and a similar ratio of I/FM to that of the other breeds. The low FM was an advantage on restricted feeding (Table 4). The Bali cattle could just maintain weight over the 280 days but the Buffalo were able to gain 95 kg. Other data demonstrate that the swamp buffalo has comparatively low growth potential (Table 5)

Table 3:
Intake and fasting metabolism of three meat producing species (Vercoe and Frisch 1979)

	Hereford X Shorthorn	Bali	Swamp Buffalo
Intake, g/kgLW/d	33	33	28
Fasting metabolism (FM) KJ/kgLW/d	101	100	82
Intake/FM	0.33	0.32	0.34

Table 4:
Gains of Buffalo and Bali cattle on restricted feed (4.8 kg/d) over 280 days

	Buffalo	Bali
Liveweight		
Initial	277	306
Final	372	320
Gain	95	14

Table 5:
Gains and adaptive traits of Buffalo and Simmental X Hereford (Frisch and Vercoe, unpublished)

	Confinement		Grazing	
	Simmental X Hfd	Buffalo	Simmental X Hfd	Buffalo
Live Weight gain, kg/d	103	0.89	0.00	0.91
BIK1			3.4	2.0
Rectal temperature			40.5	39.2
Tick count			388	4
Worm EPG1			281	10

[1] See Table 2 for explanation

but has very high levels of adaptation to the stresses operating in the Rockhampton environment. Under low stress conditions in pens, the buffalo could not gain as rapidly as the Simmental x Hereford. However, the Simmental x Hereford had low resistance to infestation with ticks and worms, could not cope with the high ambient temperatures, some animals developed BIK, and consequently over the 100 day period they failed to gain. The buffalo on the other hand gained as much in the paddock as they had in pens. This is to be expected as the trial was conducted during summer (the wet season) when feed was lush, the buffalo could cool themselves in wallows, and because they were almost completely resistant to the other stresses, they could express their full growth potential. This should not be interpreted as meaning that the swamp buffalo is completely resistant to all environmental stresses which affect production. They are not e.g. buffalo calves are quite susceptible to Neoascaris vitulorum and deaths may result from heavy infestation (Griffiths 1974). Nor are buffalos completely resistant to diseases, e.g. Haemorrhagic scepticaemia (though the vaccine is very effective in controlling the disease). Buffalo are also prone to suffer heat stress when exposed to solar radiation and denied access to a wallow or cooling shower (Frisch, unpublished data). Despite these shortcomings there are many areas of the tropics to which the various breeds of buffalo are still among the best adapted of the domestic animals.

Improvements in production of the buffalo can therefore be considered in terms of improvements in productive potential and the level of adaptation. With beef cattle, techniques are already being used to identify animals or 3 breeds which are highly heat tolerant, highly resistant to particular parasites or diseases, best able to cope with fluctuating planes of nutrition or which have high growth potential, Similar techniques could also be applied to buffalos . Identification of particular attributes of breeds would allow a rational decision to be made as to which breeds should be crossed to increase the frequency of desirable characters. It is generally true that improvements in productivity are more readily obtained by crossbreeding than by selecting in a population in which the frequency of the desirable genes is low. However, crossbreeding is only the first step and selection for the desirable characters is then necessary to improve the crossbred population. Those components of production in which particular facets of improvements in production will be considered are milk yield, and growth, survival and fertility rates. Improvement in draft power will not be considered separately. Many of the major cattle beef breeds were evolved for draft purposes and there does not appear to be any reason to believe that improving the growth rate of the buffalo will not also improve the draft capacity.

Consider the effect of some of the adaptive traits on the production.

Heat Tolerance:

There is general agreement throughout the literature that buffalo are in sufficiently heat tolerant and reports indicate (see Mason 1974) that milk yield, growth and fertility are all reduced during periods of high ambient temperature. Each of these variables shows a direct relationship with rectal temperature (Turner 1962 and unpublished; Goswani and Nair 1964) and will consequently increase with improvements in heat tolerance. Whilst short term relief of heat stress can be achieved by sprinkling or wallowing, both of which have disadvantages, any long-term improvement must come from the genetic improvement of heat tolerance.

The heat tolerance of an animal is dependent on a number of factors including how much heat the animal produces and how efficiently that heat is dissipated. Selection for low rectal temperature alone will tend to favour animals with low heat production, i.e., low metabolic rate and consequently low growth potential (Frisch 1979). Potential milk yield may also be lowered. Any attempt to improve heat tolerance must discriminate between improvements relating to heat production and other components including heat dissipation, e.g. selection for improved efficiency of evaporative cooling should improve heat tolerance without affecting heat production. The techniques which allow this to be done in cattle are currently under investigation.

Parasite and Disease Resistance

Many of the major diseases of buffalo can be effectively controlled by vaccination and it would be unprofitable to direct selection towards improving resistance to these diseases, unless a favourable response is likely to be rapid. On the other hand, the use of chemical control of parasites is a recurring, costly practice and may be a disadvantage in the long-term. Ticks and helminth species have both developed resistance to chemical treatments. Naturally resistant animals would be of benefit to everyone involved in buffalo production. With cattle, increases in resistance to cattle ticks

(Utech et al 1978) gastrointestinal helminths and BIK (Frisch 1979) have been achieved by selection either directly for the character or by indirect selection, This provides evidence that selection for similar attributes would be successful in buffalo populations,

It also appears from our own work that:the swamp buffalo is largely resistant to Oesophogostomum radiatum though it has been reported from Italy that the same species can cause heavy infestation resulting in weight loss and sometimes death (see Griffiths 1974). If the differences between these buffalo breeds is truely genetic, there is every reason to believe that there are similar differences in resistance to other parasites and disease which could be used to advantage in improving buffalo stock. One of the problems associated with selection for resistance is that in many cases, resistance declines or breaks down completely as the plane of nutrition declines. Selection for resistance on high planes of nutrition may not therefore confer resistance on low planes of nutrition or when levels of other stresses are high. Also, selection for resistance alone should favour animals which can best cope with low planes of nutrition, i.e., animals with low maintenance requirements and consequently low growth potential. The techniques for the most effective selection procedures still need investigation.

Milk Yield:

In considering improvements in milk yield, discussion refers to the river breeds only. To raise the potential milk yield of the swamp buffalo to that already existing for the river buffalos would take several human generations and it is far more efficient to increase potential yield of the swamp buffalo by crossing to the river breeds. If the swamp buffalo has adaptive traits not possessed by the river breeds and which affect production, any system of crossbreeding or upgrading must also incorporate selection for these traits.

In the large milk colonies or large herds, there seems no apparent reason why standard techniques of selection for increased milk yields by progeny testing should not be applied, This assumes that herd replacements will come from within the population under selection. However, partly as a consequence of long intercalving intervals, a practice often adopted is to buy lactating replacements from outside sources. If the side herds are reared under high levels of environmental stress, i.e. the adaptive traits determine the level of production, improvements through the use of progeny tested bulls are likely to be small. Any substantial improvement is only likely if environmental conditions are improved to the level which allows the animal to express its increased potential.

Improvements in milk potential are unlikely to be expressed under most conditions without a concurrent improvement in heat tolerance. High milk yield is associated with high feed intake and thus a high heat load. This heat load can be reduced by the provision of wallows or showers but the long term solution is to improve heat dissipation of the animal itself.

Fertility:

Fertility is generally regarded as a lowly heritable trait. This is true of populations which have been under selection for a considerable time under low to moderate stress conditions. Potential fertility is then high and disturbances are caused by environmental effects. In populations which are exposed to high levels of stress, scope exists for improvements in fertility related to improvements in adaptation. Improvement of heat tolerance has previously been mentioned as one way of lifting fertility where the cause of the lowered fertility is heat stress. This has been demonstrated at Rockhampton with cattle. However, the capacity to change inherent fertility levels has been shown to be far more difficult. Approximately three generations of selection have not detectably raised the level of the least inherently fertile breeds at Rockhampton, i.e., those based on the American Brahman. Again, however, it is likely that buffalo breeds differ in their inherent levels of fertility. This allows scope for combining high inherent fertility with high level of adaptation which will allow any increase in inherent fertility to be expressed.

Growth Rate:

The same general principles as those mentioned for cattle apply to buffalo and once the main environmental limitations to growth rate in any region are known, it is a matter of deciding whether increases in growth potential or the adaptive traits will give the desired increase in growth rate. Some discouragement should be given to the practice of selecting buffalo bulls in feedlots where growth potential is a major determinant of growth, and then expecting their progeny which are reared under highly stressful village conditions (where the adaptive traits exert their effects) to perform ina satisfactory manner. In the absence of any breed which combines both nigh growth potential with high levels of adaptation, separate strains or breeds should be selected to suit the different environments.

Survival Rate:

Work at Rockhampton has shown that cattle breeds differ in mortality rates at various stages of the life cycle. Differences between breeds in deaths which occur after the first week of life are largely due to differences in adaptation to environmental stress. Differences in perinatal mortalities (i.e., up to one week of age) are due to other causes, many of which have not been identified, e.g. Brahman calves have high perinatal mortalities but low mortalities after that time compared to the other breeds at Rockhampton. Presumably, similar differences could be identified between buffalo breeds and use made of any differences, particularly in cross-breeding schemes. Poor survival rates during the first few months of age cause such losses as to warrant more detailed study. Any such study should attempt to identify the causes of mortalities at each stage of the life cycle. Once the major areas of loss and the causes of these losses have been identified. soundly based decisions can be made towards improving overall survival rate . Some losses are doubtless due to poor husbandry practices which cannot be corrected by genetic means. Even improvements in parasite and disease resistance may not cause any major increase in survival unless the plane of nutrition is sufficient to allow the maintenance of resistance. Only well considered research effort will find out.

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