Evaluation and Utilization of Tropical Breeds for Efficient Beef Production in the Tropics: Challenges and Opportunities

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Summary

Crossbreeding results between tropical breeds and European beef breeds as well as within breed (mainly Zebu) genetic variability for some economically important traits is reviewed. Heterosis of between 9% to 11% has been reported for preweaning growth rate, 2% to 11% for postweaning and carcass traits as well as up to 15% for reproduction related traits in crosses involving Bos indicus and Bos taurus cattle. Maximum heterosis was observed in crosses involving Zebu and Criollo cattle, both well adapted to the tropics. Within breed genetic parameter estimates under tropical conditions are still scanty. Based on the production environments and after a review of the literature possible research opportunities and challenges in animal breeding and genetics related to the tropics are discussed.

Introduction

Beef production in the Latin American tropics is based on either specialized intensive ranching or the dual purpose system. The earlier system normally utilizes Bos indicus (referred to in this text as Zebu), Bos taurus beef breeds (referred to as European), Bos taurus breeds adapted to the tropics (referred to as the Criollos) or crosses involving Zebu, European and Criollos. The latter system is based on crosses between Zebu types and specialized dairy breeds for the production of both milk and beef. About 40% of the beef in the tropics is produced by the dual purpose system while the rest comes either from specialized intensive ranching and to a certain extent from dairy production systems (CATIE/BID, 1983).

The tropics are generally known for their adverse environmental conditions including high solar radiation and humidity, diseases and parasites, inadequate nutritional levels, drought and flooding to which the cattle have had to adapt. Hickman (1979) indicates that this adaptation has occurred through a lowering of production and reproduction levels from those of the temperate zones. This has meant long calving intervals, low fertility, high calf mortality delayed at age at first calving and attainment of mature weights. Several isolated research projects in beef production have been carried out in the Latin American tropics mainly with the intention of increasing the production and reproduction levels of cattle. Most have involved crossbreeding systems using zebu, European and criollo cattle (Luna, 1964; Plasse et al, 1968; Muñoz and Martín, 1969 ab; León Velarde et al; 1976; Madalena and Hinojosa, 1976; Bailon et al, 1976). Very little research has been done in the tropics in the area of selection schemes except for some isolated genetic parameter estimations made using field records. The objective of such estimates has been to evaluate breeds in terms of the genetic variability they possess for certain traits. In addition to the above, attempts to increase overall production have been made by increasing cattle populations (FAO, 1983) without much success.
The objective of this review is to summarize results on tropical breed and crossbreeding evaluation and utilization with respect to growth and reproduction in beef cattle as well as to point out possible research challenges and opportunities in the Latin American tropics.

**DISCUSSION**

Crossbreeding Performances from Beef Cattle in the Tropics.

In beef production, the breeds that have generally been studied in planned experiments or by using field records have been zebu, european and criollo. The criollo were originally introduced into Latin America by the Spaniards and Portuguese during the 16th century (Plasse, 1981). The capacity of the tropical breeds for beef production has been studied and evaluated through crossbreeding systems that have involved i) zebu x criollo; ii) european x (zebu x criollo); iii) european x zebu and iv) zebu x zebu (Plasse, 1983). In this review, results from work done in several Latin American countries were considered. In general he reported heterosis values of 9%, 12%, 11%, 30% and 16% for birth weight, preweaning average daily gain, weaning weight, post-weaning average daily gain and post weaning weight, respectively by crossing criollo and zebu. Age at puberty and pregnancy percentage had heterosis values of -11% and 14% (averaged from two lactations), respectively. When the F1 (Zebu x Criollo) females were crossed back to Zebu, Criollo or Charolais they produced 14%, 5% and 22% heavier calves at weaning, respectively than the purebred Zebu and Criollo cows. All of the above values are unweighted means. In a previous work, Plasse et al, (1975) also reported an increase in the number of cows calving per number of cows exposed to a bull when crossing Criollo x Zebu over that of pure Zebu and Criollo. In general, in the tropics but without regard to location differences, it is evident that crossing Zebu and Criollo is advantageous for pre-and post-weaning growth as well as for fertility and maternal traits. In addition the above results shed some light on the possible advantage that could be obtained by considering european beef breeds, such as Charolais in well planned crossbreeding schemes. More importantly, the results show that the Criollo x Zebu crosses have higher performance levels being themselves well adapted to the Latin American tropics. This emphasizes the urgent need for breed and germplasm conservation and evaluation under tropical environments as has been discussed by Phillips (1981).

Crossbreds from european breeds, Criollo and Zebu have been found to have better growth, better fertility, shorter calving intervals and better mothering abilities as measured by calf growth (Luna, 1964; Plasse et al, 1968; Muñoz and Martin, 1969 ab; Plasse et al, 1975; Madalena and Hinojosa, 1976; Duarte, 1985). Work done in the wet and humid tropics of Costa Rica under grazing conditions comparing weights at birth and weaning of Santa Gertrudis (SG), Brahman (BR), Criollo (CR) and their reciprocal crosses showed different heterosis values for birth weight, slaughter weight and carcass weight depending on the specific cross involved (Muñoz and Martin, 1969 ab). These authors have reported heterosis values of 6.59%, 0.52%, 7.57% for birth weight of calves (both sexes) involving BR-SG, SG-CR, BR-CR crosses, respectively. Heterosis values for weaning weight of calves were 9.12%, 3.71% and 10.56%, for crosses involving BR-SG, SG-CR, BR-CR. In the same work, heterosis values for slaughter weight and carcass weight were 11.0% and 1.5%, 15.0% and 1.8%, for the crosses involving BR-SG, SG-CR and BR-CR. From these results it is clear that crossing BR and CR results in higher heterosis value than the others.
for preweaning growth and carcass traits with the exception that the SG-CR crosses resulted in higher heterosis value for carcass weight. Difference between dam breeds for birth weight and weaning weight revealed the maternal inferiority of BR females compared to SG and CR (Muñoz and Martin, 1969 a). A previous study from the same location and genetic groups as the above showed similar heterosis values for birth weight and weaning weight (Luna, 1964).

Although, the heterosis levels shown above depend on the type of cross and therefore indicate a possible interaction between heterosis and breeding group, they still reflect higher heterosis in the tropics than those documented by Warwick (1968). For example the weighted average heterosis value for weaning weight was 4.6% in crosses involving British breeds. The possibility of high heterosis in the tropics for growth rate, viability of crossbred calf, fertility and mothering ability of the crossbred cow was discussed by Rendel (1978). The fact that higher heterosis is observed in the tropics could mean that the breeds involved are genetically divergent thus provoking such large increases in performance. If this is the case, it is surprising to see that Criollo cattle (Bos taurus) introduced into Latin America only in the 16th century still show advantageous combination when crossed with the zebu, e.g. Brahman. The possible genetic consequences of heterosis was explained by Willham (1970) and its basis by Dickerson (1969). From the previous results, it should be noted that crossbreeding plays a very important role in beef production systems within the tropics and most of the results from crossbreeding have come from different locations although, still within the tropics. The latter could influence the results observed if important heterosis by location interaction exists. In fact it is obvious from Plasse (1983) that heterosis values varied from location to location.

In most of the crossbreeding work coming from the Latin American tropics at least as far as the present review could identify, it seems that interest has generally concentrated on growth performance and reproduction, with little attention paid to other components of adaptability as they apply to cattle in the tropics. Such components include resistance to direct climatic stress (heat and humidity), resistance to disease and parasites among others. This is particularly important if the advantage of crossbreeding is looked at from the point of view of maximizing total output per female. In addition, no work could be identified in the literature concerning production efficiency (including costs) related to crossbreeding systems. Work from Australia (Turner and Short, 1972) indicates that crosses involving Bos indicus resist better external parasite infestation. For example Bos indicus x Bos taurus carried less external parasites (mean of 20-30 ticks per side) than those Bos taurus x Bos taurus crosses (mean of 75-100 ticks per side). Those crosses involving Bos indicus suffer less from environmental adversity and therefore are more suitable biological types under conditions where there are such parasite problems. Little is known about such resistance in the region considered in this review.

Genetic Variation within Breeds in the Tropics.

In the Latin American tropics breed evaluation has mainly been based on the analyses and interpretation of field records. Traits mostly evaluated on a within breed (mostly zebu types) basis include growth traits such as birth weight, weaning weight and preweaning growth rates as well as reproductive traits such as calving intervals, services per conception (where such data are availa-
ble) and age at first calving (Bailon et al., 1976; Berruecos et al., 1976; Borsotti, 1976; León-Velarde et al., 1976; Verde and Plasse, 1976; Proal and Tewolde, 1982; Duarte, 1985; Silerio and Tewolde, 1985). In most of these studies heritabilities \( h^2 \) and to a certain extent repeatabilities of the traits were estimated. Heritability estimates varied from 0.28 to 0.35 for weaning weight of calves (mostly Brahman) while those \( h^2 \) estimates for birth weights (also mostly in Brahman) ranged from 0.20 to 0.34. Heritability estimates for birth and weaning weights in Indobrasil and Gyr are within the ranges found in Brahman (Proal and Tewolde, 1982; Silerio and Tewolde, 1985). Repeatabilities of birth weight and weaning weight also ranged from 0.24 to 0.4, while for those related with reproduction ranged from 0.10 to 0.45. The literature indicates that there is very little experimental work whose final objective was to generate estimates of genetic parameters for various economically important traits for beef cattle in the tropics. Rendel (1978) noted that little is known about the \( h^2 \) under tropical conditions, which is still probably true today.

The above \( h^2 \) estimates, despite their limitations, however, reflect the existence of sufficient genetic variation for growth traits in the tropics to warrant selection. Barlow (1978) indicates that selection for either weaning weight or average daily gain to weaning can increase live weight at all ages from birth to maturity although he does not specify the breed or breed groups. This may be so, because weaning and pre-weaning growth have received more emphasis where animals are finished on pasture than growth after weaning. In the case of the Latin American tropics too, animals are generally finished on pasture. The overall effect of selecting for weaning weight on female reproduction could, however, be negative as mentioned by Barlow (1978). Such information is little known in the tropics. Very little work has been done in total lifetime cow productivity in such areas. Ornelas (1985) reported a positive phenotype correlation (0.33) between a cow's own weaning weight and total kilo weaned by herself for Indobrasil (Zebu) cattle in the Mexican tropics. However, the value was not significantly different from zero. Again it should be realized that Ornelas' (1985) data came from field records.

Morris (1980) did an extensive review of the possible advantages that could be obtained in lifetime production where breeding of heifers is practiced at a younger age. Although most of his survey was largely based on breeds of European origin, these data from New Zealand (where production conditions are based on pasture) could be relevant to the Latin American tropics where similar management conditions are employed. In the same area of concern Baker et al. (1980) from New Zealand reported preliminary results in Angus and Hereford cattle showing clear evidence of the possibility of selecting for yearling weights with positive correlated responses in growth. In this study the growth traits considered were weights at birth, weaning, 13 months of age and 18 months of age. In addition, it was shown that each of the growth traits was responsive to direct selection.

In the tropics, the weaning and pre-weaning growth traits of Zebu as also measures of maternal ability have been found to be heritable, but there is very little information regarding the correlation between additive genetic and maternal genetic effects in the literature concerning the tropics. In this regard Crail (1985) working with Indobrasil field records in the Mexican tropics reported a genetic correlation of -0.26 between weaning weights of heifers and the post-weaning growth of their paternal half brothers. The correlation was
not significantly different from zero. Also, Muñoz and Martin (1969a) using differences between breeds of dam were able to conclude that the Brahman has poor maternal ability for birth weight and weaning weight, the Santa Gertrudis having the best maternal ability and the Criollo being the intermediate. Using the breed of sire difference and breed of dam difference it can be roughly shown that the correlation between breed additive and breed maternal genetic effects tends to be negative although close to zero. Several investigators have reported genetic correlations between additive genetic and maternal genetic effects on preweaning growth traits in Bos taurus beef breeds and in some Bos taurus x Bos indicus crosses. (Deese and Koger, 1967; Brown and Galvez, 1969; Hohenboken and Brinks, 1971; Koch, 1972; Dillard et al, 1980). In general, even though there was a tendency for negative antagonism between additive and maternal genetic effects they seem to conclude that such antagonism is close to zero.

In the Latin American tropics, knowledge of such correlations may be very useful especially in the dual purpose system. As indicated earlier, about 40% of the beef in the tropics is produced in a dual purpose system utilizing the types of animals mentioned earlier in this review. The possibility of using crossbred sires is very attractive even though there is no sufficient data to compare them with straight bred sires for the improvement of beef and dairy production.

Challenges and Opportunities

In the foregoing discussion results from the literature have been presented for various traits of economic importance in beef production in the tropics. Also, an attempt has been made to review literature regarding the available breed resources in the tropics. From these, and considering the present factors that affect the efficiency of beef production it is advisable to point out the challenges and opportunities that exist in relation to the breed resources of the tropics for efficient beef production.

Some of the challenges in using the breed resources include: i) development of breeding programmes and strategies of animal improvement compatible to the reality of the tropical regions. The present reality of the Latin American tropics is that production per animal unit is still very low and cost of production is very high. ii) Identification of the major constraints for animal improvements in the Latin American tropics is needed. iii) Conservation programmes of the Criollo type breeds well adapted to the tropics is required in view of the promising results that they have shown in crossing with zebu. However, such programmes, should compare critically the biological efficiency of the Criollos with other alternative breeds. In this case the small population size of the criollos may be seen to be a problem, but this could be partly solved through use of modern biotechnology such as that of embryo transfer. Nicholas and Smith (1983) estimated a rate of genetic improvement in dairy of up to 30% if 1024 transfers could be made per year and milk record of 512 females is registered annually.

The existing opportunities to increase beef production in the Latin American tropics could be summed up as the following: i) More work on breed evaluation is needed comparing the Zebu, Criollo and other European beef breeds under different management and nutritional conditions (genotype by environment interaction) to guarantee sustained improvement over wider ecological zones within the tropics itself. ii) Study of total cow productivity as a maternal trait
in each of the breeds and its relationship with the cow's own weaning or yearling weight. Also needed is the study of the effect of heterosis on total cow productivity. iii) Consider the existing beef production systems, specialized beef production and dual purpose system, in studying and determining the role that the existing breed resources play in each system. Special attention should be given to the dual purpose system as it is not yet clear how much weight should be given to the milk production component and how much to the beef production component. This is particularly important in view of the fact that such weights may vary depending on the specific country within the tropics under consideration. Such research is totally lacking in the region under consideration. iv) Comparison of total productivity between purebred and crossbred sires under tropical conditions. v) A very good opportunity exists, without considering for the time being the cost involved in studying the genetic potential that tropical breeds have for disease and parasite resistance. There is evidence that resistance to external parasites, such as ticks, is more heritable in Bos taurus (Seifert, 1971) at least under the Australian conditions. Such work could greatly improve the level of beef production in the Latin American tropics.

CONCLUSION

In conclusion it can be said that the breeds adapted to the tropics including Bos indicus (Zebu) and Bos taurus (Criollo) have appreciable performance which could still be increased by considering other european beef breeds in a carefully designed crossbreeding system. It can also be concluded that most genetic parameter estimates reported for different economically important traits in the tropics are not from experimental data. However, they reflect sufficiently the existence of genetic variability so as to implement well defined breeding programmes to be in effect. Finally, it is obvious that more work is needed to be done in the Latin American tropics to increase beef production on a per animal unit basis.

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