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# The Use of Composite Bulls – Long Term Benefits and Challenges

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# THE USE OF COMPOSITE BULLS - LONG TERM BENEFITS AND CHALLENGES

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## INTRODUCTION

Composite bulls won't perform magic or offset poor management but they offer a tool to help solve production/management problems and optimize production for a wide range of environments.

The impact of crossbreeding through heterosis (hybrid vigor) and utilization of breed differences (complementarity) for major traits like reproduction, calf survival, maternal ability, growth, longevity and other fitness traits is powerful. The cumulative effect of crossbreeding can increase calf weight weaned per cow exposed by 20 percent.

Conventional crossbreeding programs fall short in "management ease" because: 1) Rotations tie up several breeding pastures; thus, complicating grazing management, 2) Identification by sire breed type is required for proper breeding pasture assignment and 3) There is a continual struggle with swings in breed composition as long as straight bred sires are used; thus, complicating heifer selection and marketing of steer progeny.

Crossbreeding, along with selection against extremes, offers a method to blend desirable characteristics of several breeds in an effort to use both heterosis and complementarity while avoiding unfavorable genetic antagonisms. Composites may be the preferred tool to implement such a crossbreeding/balanced trait selection program.

## BENEFITS OF USING COMPOSITE BULLS

1. Simplifies total management since only one breed type is maintained on the ranch.
2. Optimizes breed composition to match production environments and market targets.
3. Utilizes complementarity between breeds in the foundation generation and also later if specialized sire and dam line composites are used.
4. Eliminates the fluctuation in breed composition between generations.
5. Provides a sustainable method to maintain reasonable levels of heterosis.
6. Allows flexibility to tap future composites that may better target the product or fit a specific production environment.
7. Paternal heterosis in semen quality/quantity, mating capacity and longevity of crossbred bulls.

## CHALLENGES TO THE USE OF COMPOSITE BULLS

1. Identification of composite seedstock sources that are adequately documented to fit a particular

environment or market.

2. Overcoming conventional thinking to develop databases for composite, hybrid and $F_1$ cattle based on field data for major bioeconomic traits.
3. Responding to the misconception that composite sires generate more variation than purebred sires at a time when uniformity and consistency are the catch words of the beef industry.
4. Dealing with the criticism that will come for lack of EPD's or alleged low-accuracy Across Breed EPD's on composite cattle.
5. Getting beyond the "our-breed-can-do-it-all" mentality of some breeds while appreciating the need for a viable purebred seedstock segment of the industry.

## BREED AND BIOLOGICAL TYPE DIFFERENCES

Table 1 shows relative differences in growth rate and mature size, lean to fat ratio, age at puberty, and milk production for a large number of breeds whose crosses have been evaluated in the Germ Plasm Evaluation (GPE) project at the Meat Animal Research Center (MARC). It is apparent from study of this table that no single breed or biological type of cattle is perfect, rather each breed has some strengths and some weaknesses.

TABLE 1. BREED CROSSES GROUPED IN BIOLOGICAL TYPE ON BASIS OF 4 MAJOR CRITERIA

| Breed group | Growth rate and mature size | Lean to fat ratio | Age at Puberty | Milk production |
|---|---|---|---|---|
| Jersey-X | X | X | X | XXXXX |
| Hereford-Angus-X | XX | XX | XXX | XX |
| Red Poll-X | XX | XX | XX | XXX |
| South Devon-X | XXX | XXX | XX | XXX |
| Tarentaise-X | XXX | XXX | XX | XXX |
| Pinzgauer-X | XXX | XXX | XX | XXX |
| Sahiwal-X | XX | XXX | XXXXX | XXX |
| Brahman-X | XXXX | XXX | XXXXX | XXX |
| Brown Swiss-X | XXXX | XXXX | XX | XXXX |
| Gelbvieh-X | XXXX | XXXX | XX | XXXX |
| Simmental-X | XXXXX | XXXX | XXX | XXXX |
| Maine-Anjou-X | XXXXX | XXXX | XXX | XXX |
| Limousin-X | XXX | XXXXX | XXXX | X |
| Charolais-X | XXXXX | XXXXX | XXXX | X |
| Chianina-X | XXXXX | XXXXX | XXXX | X |

Number of X's indicate relative amount of each trait.

## MATCHING GENETICS TO RESOURCES

Table 2 presents an attempt by the Beef Improvement Federation (BIF) to characterize production environments and estimate optimum productivity within those environments. Production environments are feed availability and environmental stress. Feed availability refers to the quantity and quality of native forage and supplemental feed. Environmental stresses include heat, cold, humidity, parasites, altitude, mud and disease. For each of the six traits listed in the table either a Low, Medium or High level is recommended for each production environment. For example, a typical range for low, medium and high levels of cow mature size might be 800-1000 lbs, 1000-1200 lbs and 1200-1400 lbs, respectively.

TABLE 2. MATCHING GENETIC POTENTIAL FOR DIFFERENT TRAITS IN VARYING PRODUCTION ENVIRONMENTS[1]

| Production environment | | | | | | | |
|---|---|---|---|---|---|---|---|
| Feed Availability | Environmental stress[2] | Milk production | Mature size | Ability to store energy[3] | Adaptability to stress[4] | Calving ease | Lean yield |
| High | Low | M to H | M to H | L to M | M | M to H | H |
| | High | M | L to H | L to M | H | H | M to H |
| Medium | Low | M+ | M | M to H | M | M to H | M to H |
| | High | M- | M | M | H | H | M |
| Low | Low | L to M | L to M | H | M | M to H | M |
| | High | L | L | H | H | H | L to M |
| Breed role in terminal crossbreeding systems | | | | | | | |
| Maternal | | L to H | L to M | M to H | M to H | H | L to M |
| Paternal | | L to M | H | L | M to H | M | H |

[1]L = Low; M = Medium; H = High
[2]Heat, cold, parasites, disease, mud, altitude.
[3]Ability to store fat and regulate energy requirements with changing (seasonal) availability of feed.
[4]Physiological tolerance to heat, cold, parasites, disease, mud, and other stresses.

The optimum trait levels shown in Table 2 are appropriate for General Purpose type cattle, cattle that are usually used in rotational crossbreeding programs. The lower part of the table lists optimum trait levels for both the maternal and paternal sides of a terminal crossbreeding program.

Greater feed availability and lower degree of stress results in a wider optimum range of milk. Optimum range of mature size also changes with range of feed availability. Environmental stress probably only limits mature size when feed availability is low.

Cows without the ability to store energy, when feed availability is low, often do not have enough body condition to rebreed quickly. Cows that do well in low feed environments may be fat cows in high feed-low stress environments. Since lean yield and ability to store fat are antagonistic, the optimum level of leanness varies with feed availability. A lean cow may be acceptable when feed is good but with limited feed, cows need to fatten easily.

Resistance to stress is always important, especially in high stress environments. For example, heat tolerance is critical in hot, humid regions. Calving ease may become increasingly important as stress level increases or other resources (labor) decline.

Recommendations for optimum trait levels for sires and dams in terminal crossbreeding systems vary somewhat from General Purpose types. Maternal cattle generally need more adaptability, more ability to store fat and less lean yield than General Purpose types. Milk production should be about the same but size should be less to take advantage of the complimentary effects of using growthier terminal sires. Calving ease is very important. Traits emphasized in terminal types are growth rate and lean yield. Milk production and ability to store energy are not very important in terminal types. Calving ease and adaptability in Terminal types is not as critical as in maternal types but should not be ignored.

## COMPOSITE BREEDS

An alternative to the more complex crossbreeding systems is the development of composite breeds based on matings among crossbred animals resulting from crosses of two or more breeds. The management of a composite breed system is simple, especially for producers who have limitations on herd size and number of breeding pastures. Only one breeding pasture would be required and no identification of females by sire or year of birth would be required. Replacement females would be generated within the system.

Composite breeds do not sustain as high of level of heterosis as do rotational systems, however composite breeds do allow for more complementarity between breeds to be utilized. For example, breeds which vary considerably in mature size, milk production and carcass merit could be utilized in forming a composite breed fitted to specific feed resources, environmental and climatic conditions.

Also to be considered is the importance of paternal heterosis, since bulls in a composite system are crossbreds too. Utilizing composite breed bulls may serve as an extra bonus, since some studies have indicated evidence for paternal heterosis in some semen traits, libido and mating vigor of crossbred bulls.

Thus, the formation of composite breeds based on a multi-breed foundation is an attractive alternative to conventional crossbreeding systems. Once a new composite breed is formed, it can be managed as a straightbred population, and the management problems that are associated with small herd size and with fluctuations between generations in additive genetic composition in rotational crossing systems are avoided.

## GENETIC BASIS OF COMPOSITE BREEDS

Retention of initial heterozygosity after crossing and subsequent random (inter se) mating within the crosses is proportional to (n-1)/n, where n is the number of breeds involved in the cross. This loss in heterozygosity occurs between the $F_1$ and $F_2$ generations. If inbreeding is avoided, further loss of heterozygosity in an inter se mated population does not occur. This expression, (n-1)/n assumes equal contribution of each breed used in the foundation of a composite breed. Table 3 provides information on level of heterozygosity relative to the $F_1$ that is retained after equilibrium is reached for two-, three- and four-breed rotation crossbreeding systems and is presented for two-, three-, four-, five-, six-, seven- and eight-breed composites, with breeds contributing in different proportions in several of the composites. Existing breeds of cattle are mildly inbred lines, and to the extent that heterosis is due to the dominance effects of genes, heterosis is the recovery of accumulated inbreeding depression.

Composite breeds offer the opportunity to use genetic differences among breeds to achieve and maintain the performance level for such traits as climatic adaptability, growth rate and size, carcass composition, milk production and age at puberty that is most optimum for a wide range of production environments and to meet different market requirements. Further, composite breeds may provide herds of any size with an opportunity to use heterosis and breed differences simultaneously.

With 55 percent of the U.S. beef breeding herd and 93 percent of the operations that have beef cows represented by units of 100 cows or fewer, there are obvious limitations on feasible options for optimum crossbreeding systems. The limitations are most significant if female replacements are produced within the herd and natural service breeding is used. Further fluctuation between generations in additive genetic (breed) composition in breed-rotation crossbreeding systems restricts the extent to which breed differences in average additive genetic merit can be used to match climatic adaptability and performance traits to the climatic and feed environment.

## COMPLEMENTARITY IN COMPOSITES

Composite breeds do not permit the use of different genotypes (complementarity) for male and female parents. However, specialized paternal and maternal composite breeds may be developed for use in production systems in which the production resource base and market requirements favor the exploitation of complementarity. Between-breed selection is highly effective for achieving and maintaining an optimum additive genetic composition for such specialized populations by using several breeds to contribute to the foundation population for each specialized composite breed. There is the potential to develop general purpose composite breeds through careful selection of fully characterized candidate breeds to achieve an additive genetic composition that is better adapted to the production situation than is feasible through continuous crossbreeding or through intra-breed selection.

TABLE 3. HETEROZYGOSITY OF DIFFRENT MATING TYPES AND ESTIMATED INCREASE IN PERFORMANCE AS A RESULT OF HETEROSIS

| Mating type | Heterozygosity percent relative to $F_1$ | Est increase in calf wt wnd per cow exposed[a] (%) |
|---|---|---|
| Pure breeds: | 0 | 0 |
| Two-breed rotation at equilibrium | 66.7 | 15.5 |
| Three-breed rotation at equilibrium | 85.7 | 20.0 |
| Four-breed rotation at equilibrium | 93.3 | 21.7 |
| Two-breed composite: | | |
| $F_3$ - 1/2A, 1/2B | 50.0 | 11.6 |
| $F_3$ - 5/8A, 3/8B | 46.9 | 10.9 |
| $F_3$ - 3/4A, 1/4B | 37.5 | 8.7 |
| Three-breed composite: | | |
| $F_3$ - 1/2A, 1/4B, 1/4C | 62.5 | 14.6 |
| $F_3$ - 3/8A, 3/8B, 1/4C | 65.6 | 15.3 |
| Four-breed composite: | | |
| $F_3$ - 1/4A, 1/4B, 1/4C, 1/4D | 75.0 | 17.5 |
| $F_3$ - 3/8A, 3/8B, 1/8C, 1/8D | 68.8 | 16.0 |
| $F_3$ - 1/2A, 1/4B, 1/8C, 1/8D | 65.6 | 15.3 |
| Five-breed composite: | | |
| $F_3$ - 1/4A, 1/4B, 1/4C, 1/8D, 1/8E | 78.1 | 18.2 |
| $F_3$ - 1/2A, 1/8B, 1/8C, 1/8D, 1/8E | 68.8 | 16.0 |
| Six-breed composite: | | |
| $F_3$ - 1/4A, 14/B, 1/8C, 1/8D, 1/8E, 1/8F | 81.3 | 18.9 |
| Seven-breed composite: | | |
| $F_3$ - 3/16A, 3/16B, 1/8C, 1/8D, 1/8E, 1/8F, 1/8G | 85.2 | 19.8 |
| Eight-breed composite: | | |
| $F_3$ - 1/8A, 1/8B, 1/8C, 1/8D, 1/8E, 1/8F, 1/8G, 1/8H | 87.5 | 20.4 |

[a]Based on heterosis effects of 8.5% for individual traits and 14.8% for maternal traits and assumes that retention of heterosis is proportional to retention of heterozygosity.
Gregory, K.E., et al. 1990.

## MINIMUM HERD SIZE FOR COMPOSITE BREEDERS

The maintenance of effective herd size sufficiently large that the initial advantage of increased heterozygosity is not dissipated by early re-inbreeding is essential for retention of heterozygosity (heterosis) in composite breed seedstock herds. Thus, the resource requirement for development and use of composite breeds as seedstock herds is high, and from an industry standpoint requires a highly viable and creative seedstock segment. Early re-inbreeding and a small number of inadequately characterized parental breeds contributing to the foundation of composite breeds have likely been major causes for failure of some previous efforts at composite breed development.

For the breeders of composite breeds, it is suggested that the number of females be sufficient for the use of not less than 25 sires per generation. Use of 25 sires per generation would result in a rate of increase in inbreeding of about .5 percent per generation. Further, a large number of sires of each purebreed contributing to a composite breed should be sampled in order to minimize the rate of inbreeding in subsequent generation of inter se mating. Inbreeding may be viewed as the "other side of the coin" to heterosis and must be avoided in order to retain high levels of heterozygosity (heterosis) in composite breeds. It should be pointed out that this constraint on minimum herd size only applies to seedstock breeders of composite breeds and no such constraint is applied to users of composite bulls which could be large or small herds.

## ALTERNATIVE MATING SYSTEMS

Examples of traditional and simplified crossbreeding systems are presented in Table 4 which shows how $F_1$ bulls can be used to reduce variation due to breed composition fluctuation within crosses. $F_1$ bulls which may be themselves the product of quite diverse matings (complimentarity) can actually stabilize the contribution of a given breed (Breed A in this example) and yet deliver very satisfactory levels of heterosis.

TABLE 4. EXAMPLE CROSSBREEDING SYSTEMS

| | | Breed A | |
|---|---|---|---|
| Crossbreeding System | Heterosis | Min % | Max % |
| 1. Rotation, purebred A & B bulls | 67 | 33 | 67 |
| 2. Rotation, purebred A, B & C bulls | 86 | 14 | 57 |
| 3. Composite A x B x C x D | 75 | 25 | 25 |
| 4. Rotation, $F_1$ (A x B) bulls and $F_1$ (C x D) bulls | 83 | 17 | 33 |
| 5. Rotation, $F_1$ (A x B) bulls and $F_1$ (A x C) bulls | 67 | 50 | 50 |
| 6. Composite, A x (B x C) | 63 | 50 | 50 |

Adapted from Bourdon, R.M., 1994.

Genetic variation in alternative mating systems is shown in Figure 1 expressed in genetic standard deviation units. Panel 1 (Figure 1) shows that genetic variation between breeds is approximately equal to genetic variation within breeds for some bioeconomic traits. For example, mean percentage retail product of Angus is approximately six genetic standard deviation units less than mean percentage retail product for Charolais.

Panel 2 (Figure 1) shows the difference between generations at equilibrium in rotation

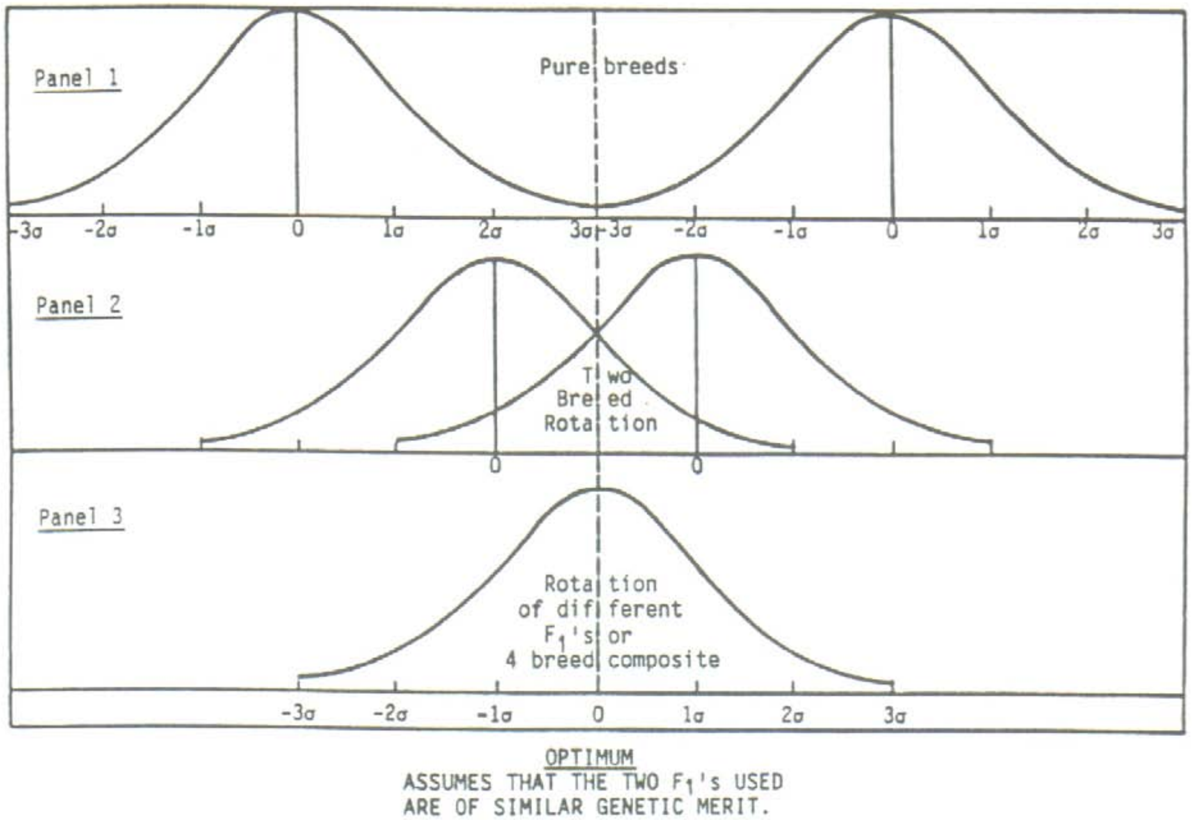


Figure 1. Genetic Variation in Alternative Mating Systems

crosses of two pure breeds that have a mean difference in a bioeconomic trait of six genetic standard deviation units. If the mean of the two breeds is optimum, then one-half of the cattle would be more than one genetic standard deviation from the optimum in a rotational crossbreeding system of two pure breeds whose means differ by six genetic standard deviation units.

Another alternative is rotational crossbreeding of $F_1$ males. This alternative has some inherent long-term advantages. Inter-generation variation (Figure 1, panel 2) can be minimized in commercial production if breeds chosen to produce $F_1$'s are selected to optimize performance levels in the $F_1$ cross. Panel 3 (Figure 1) reflects the genetic variation expected with rotational crossing of AB and CD $F_1$'s where A and C represent a common biological type and B and D another common biological type.

Thus, a rotational crossbreeding system using $F_1$ males produced from different breeds (e.g., either AB-CD or AB-AD) is preferred to a rotational crossbreeding system using two pure breeds for using breed differences to achieve a more optimum additive genetic (breed) composition.

## SUMMARY

Composite bulls from superior parents and parental breeds selected for environmental adaptability/market fitness and screened for major traits in large contemporary groups have much to offer the commercial beef producer. The need to optimize breed composition to match production environments and market targets is important but difficult with the rotational use of purebred sires. The tremendous variation that exists between and within breeds is not a curse but an opportunity for those willing to make a paradigm shift in their approach to their breeding program. Progeny of composite bulls follow a normal distribution that is no more variable than purebred bulls of the same parental breeds. Documentation of composite sources and databases will be key factors in determining the extent that composite bulls will be used.

## REFERENCES/RECOMMENDED READING

Bourdon, Rick. 1992. Prioritizing trait selection. Proc. Beef Improvement Federation Annual Meeting. May 6-9, Portland, OR. p. 103.

Bourdon, Rick. 1994. Breed roles, in hitting a new target. Proc. Beef Improvement Federation Annual Meeting. June 1-4, Des Moines, IA. p. 115.

Cundiff, L.V., K.E. Gregory and R.M. Koch. 1989. Evaluation of maternal, growth and carcass characteristics of diverse breeds. Proc. Applied Animal Breeding Seminar. Meat Animal Research Center. August 23-25, Hastings, NE. p. 33.

Gosey, J.A. 1994. Composites: A beef cattle breeding alternative. Proc. Beef Improvement Federation Annual Meeting. June 1-4, Des Moines, IA. p. 93.

Gosey, J.A. 1991. Crossbreeding systems and the theory behind composite breeds. Proc. Range Beef Cow Symposium XII, December 3-5, Fort collins, CO. p. 33.

Gosey, J.A. 1987. Breeding specification cattle for the future. Proc. Range Beef Cow Symposium X, December 8-10, Cheyenne, WY. p. 218.

Gregory, K.E., L.V. Cundiff and R.M. Koch. 1993. Composite breeds - What does the research tell us? Proc. Range Beef Cow Symposium XIII, Cheyenne, WY. p. 13.

Gregory, K.E., L.V. Cundiff and R.M. Koch. 1993. Germplasm utilization in beef cattle. Beef Research Progress Report No. 4. Meat Animal Research Center. p. 7.

Gregory, K.E., L.V. Cundiff and R.M. Koch. 1993. Use of crossbreeding and breed differences to meet specific targets for production and carcass traits of beef cattle. Beef Research Progress Report No. 4. Meat Animal Research Center. p. 20.

Kress, D.D. 1989. Practical breeding programs for managing heterosis. Proc. Range Beef Cow Symposium XI. Rapid City, SD. p. 44.

Kress, D.D. and T.C. Nelsen. 1988. Crossbreeding beef cattle for western range environments. Nevada Agr. Exp. Sta., TB-88-1. p. 31.

Leachman, J.L. 1993. Optimum mainstream crossbreeding systems. Proc. Range Beef Cow Symposium XIII. Cheyenne, WY. p. 32.

Ritchie, H.D. 1995. The optimum cow - What criteria must she meet? Proc. Beef Improvement Federation Annual Conference. Sheridan, WY. p. 126.

Using the systems concept for beef improvement. 1990. Beef Improvement Federation Guidelines. pp. 70-71.