The Role of Dairy Cattle Genes In United States Beef Production

ABSTRACT

Cattle carrying genes from dairy breeds or dairy-beef crossbreds make up 20 to 25% of the United States beef supply. Dairy breeds may contribute desired growth and milk traits, but compared to beef breeds at equal finish they have lower dressing percent, ratio of gain to feed, and cutout percent; overall palatability of the beef is close to equal. Dairy cows have higher maintenance requirements, longer postpartum intervals, and more teat and udder problems. Cull dairy heifers and cows bred to beef sires for special purposes may be utilized to a greater extent. Crossbred dairy-beef cows may create a desirable blend of traits and exploit heterosis and complementarity. However, a continuous flow of genes from dairies to the beef supply except as a by-product does not appear likely in the short term. Diverting any selection differential from dairy to beef characters, except those of dual benefit, such as calving ease, does not appear warranted. For the long term, research to quantify and clarify cause and effect relationships among characters such as milk production, ratio of muscle to bone, maintenance requirements, appetite, and gastrointestinal tract capacity should have high priority, because the results would be useful for both dairy and beef production.

INTRODUCTION

Pathways by which genes of dairy cattle affect the supply of US beef are varied and circuitous. All cattle produce beef carcasses, and all normal cows produce milk so that the distinction between dairy and beef breeds is one of convenience based on primary use. Use of the term "biological type" is of recent origin; it usually refers to potential for size, maturation and growth rates, and milk yield. For this review, I defer to traditional definitions of beef and dairy breeds while recognizing that these terms are ill-defined and may have prejudicial connotations.

Dairy and beef cattle production systems, as well as incentives and motives of owners of these enterprises, may differ. Both of these animal production systems have changed over the past 10 yr, and the next 10 yr portend even greater change. Dairy production tends to be more intensive and more dependent on consistent cash flow and profit. Beef production is influenced more by land management considerations, especially utilizing land suitable only for grazing, and concerns such as tax shelter, hobby, and venture capital (65). Beef cattle production, although cyclic, lacks sensitivity or responsiveness to supply and demand. As an industry, the profit margin for beef cattle producers has been close to zero for a decade, and predictions indicate little change for the near future (38, 51). Historically, if beef production is divided into cow-calf, stocking, feeding, and packing stages, only one of these components tends to prosper at any one time (85). Dairy beef production may be considered a by-product and, therefore, lacks sensitivity to supply and demand of beef. The observation has been made that although it is true that we consume all of the beef produced, we also produce all we consume (64). Trends of per capita meat consumption in the US have been relatively stable for about 10 yr, but beef has become a smaller proportion of total red meat and poultry consumption; population increase will have a counterbalancing effect, but total US beef consumption probably will remain close to or fall a little below present consumption (51, 86). Real per capita income is the key factor in shifting beef demand (86). These observations and predictions indicate that for beef production to be profitable in the

Received October 6, 1982.
future, as a mature rather than a growing industry (51), production efficiency must be increased.

I should like to review the role of dairy cattle genes in US beef production by first examining some basic points related to carcass and meat characteristics and beef production characteristics of dairy vs beef breeds. After basic biological differences are established, this base will be used to examine genetic aspects of dairy herds producing beef as a by-product or dual product (along the lines of the European model) and then to consider effects of the flow of genes from dairy breeds into beef herds especially via crossbreeding.

CARCASS AND MEAT CHARACTERISTICS

The majority of reports about carcass and meat characteristics of beef from dairy breeds include only the Holstein (or related strains) as a dairy breed and relate to dairy-beef breed crosses and treatment effects such as nutrition. Nevertheless, the results, taken as a whole, provide a basis for definitive comparison of carcass and meat characteristics from the traditional US dairy vs beef breeds.

Eating qualities of beef that generally are accepted as criteria are flavor, tenderness or shear force, juiciness, and overall acceptability or palatability. If weight, age, and degree of fatness are equal, no real differences between dairy and beef breeds for these criteria are apparent (62, 64). However, these restrictions are difficult to obtain experimentally, and results would be difficult to interpret. For example, if Holstein, Brown Swiss, Jersey, Hereford, Angus, and Charolais cannot be produced at equal weights, ages, and degrees of fatness, biological or commercial meaning of breed comparison is indeterminate. There is evidence, obscured by this problem, that round steak from Holstein is measurably less tender (75, 91). The advent of electrical stimulation of carcasses to improve color and tenderness now is used commercially and reduces earlier concerns about small differences of tenderness (66, 67, 71). There are no other differences of meat characteristics that have been demonstrated consistently.

Long standing criteria for carcass evaluation have been United States Department of Agriculture (USDA) quality and yield grades. These grades have had an important role in the beef industry, but both are composites of several characteristics and are of limited value for gaining an understanding of biological differences between breeds. Also, quality grade standards were changed in 1975 (80), and recent actions indicate that these standards may be reconsidered (81). There is a trend for major retail chains to utilize quality grades less for purchasing and merchandizing of beef. If each breed is finished to about the same percentage of carcass fat, then many differences, other than weight, disappear. Several important differences remain (4, 7, 15, 23, 24, 28, 42, 63, 64, 91); these differences are summarized below in terms of dairy breeds deviating from British beef breeds: 1) dressing percent is lower because of larger gastrointestinal tract and greater fill, 2) fat distribution is about equal fat thickness over loin, less thickness for the remainder of outside fat, more kidney and pelvic fat, and somewhat less marbling than Angus, 3) lean distribution shows little difference between ratios of weights of muscles or cuts, lower ratio of muscle to bone; and loin eye tends to taper at distal end, reducing acceptable steaks that can be cut from loin eye. None of these disadvantages of dairy breed carcasses is sufficiently great to eliminate incentives to finish dairy breeds similar to beef breeds.

A trend of the beef packing industry, in addition to less use of USDA grades, is that of packing wholesale cuts in boxes (51). Production efficiency of the packing process favors large carcasses so that desired carcass weights have increased from 260 to 300 kg to around 325 to 350 kg, and predictions indicate that 400 kg and heavier carcasses will become acceptable or even desired for boxed beef. Another trend is toward leaner beef (51). If trends toward larger carcasses and leaner beef continue, carcass disadvantages of the large dairy breeds, e.g., Holstein and Brown Swiss, will lessen. However, more standardized processing procedures may permit less flexibility of the carcass product without penalties that in turn affect production practices. For example, these trends indicate that finishing Jerseys as bulls, rather than as steers, followed by electrical stimulation of the carcass, may be necessary to avoid penalties for small size or excessive fatness.

The trend for an increasing percentage of
beef in the US to be consumed as ground or sausage meat apparently has plateaued (83). Deboning of entire carcasses has proven to be uneconomic except for cull cows and bulls. Carcasses from young bulls have become more acceptable because of electrical stimulation (66, 57), desired leaness, and new product development (51). Apparently, it is uneconomic to produce bull carcasses unless the steak and roast meat is separated for sale at a higher price.

It is significant that only recently has a major national retailer eliminated a policy of not purchasing Holstein steers or steer carcasses for block beef (G. C. Smith, personal communication). Price differentials of the past were not fully objective and are disappearing.

**PRODUCTION EFFICIENCY**

Problems of comparing productive efficiencies of dairy and beef breeds are similar to, but greater than, those for comparing meat and carcass characters, and conclusions about differences are less clear. Beef production systems have been divided into two phases, reproduction (Phase 1; increase of numbers) and production (Phase 2; increase of weight and finish). Three characters have direct and pervasive correlated effects on efficiency of cattle production systems: size, maturing rate independent of size, and milk yield. These primary characters account for much of the variability of net efficiency of beef production systems including effects of reproductive performance (19). The US dairy breeds have genetic potentials for relatively fast maturing rates and high milk yield but are of variable body size. Traits that contribute to efficiency of beef cattle production systems for Phase 1 are principally cow traits: adapted and hardy, high fertility, low maintenance requirements, moderate milk production, early puberty, and productive longevity. Phase 2 includes principally slaughter animal traits: high daily gain, efficient feed conversion, and a high cutout, desirable carcass.

Traits contributing to efficiency in Phase 1 are not all compatible with those contributing to efficiency in Phase 2 (17). For beef cattle, selection of a breed based on either the desired cow herd traits or desired meat animal traits is not logical because each is only a component of the total production system. Herd productivity, measured as herd O/I (output per unit of input) in either biological or economic terms, is maximal when these traits are balanced (8, 18, 19, 20, 46, 56, 57, 70). Thus, assessments of the comparative efficiency of dairy breeds must account for interactions among Phase 1 and 2 characters; e.g., weaning weight (milk production) and postpartum interval.

Rate of gain during the growing/finishing phase of beef cattle has been compared as a biological and economic parallel to milk production of dairy cattle, but this analogy is inappropriate. Rate of gain tends to be highly correlated with size; i.e., weight at any age or stage of maturity, such as puberty, tends to be directly proportional to mature size (50, 77). Cattle of breeds that are different in size when grown and finished to their optimal weight and degree of finish tend to be equal in O/I measures such as feed required per unit of gain (40, 46). Important differences of efficiency remain and depend on such items as feed cost and market demand, but the differences, except for weight, are smaller than those from feeding for equal lengths of time or to equal weights (73). Heritabilities for final weight or mature size have been estimated to be generally in a range above .5 (13, 14, 16, 44); these high heritabilities indicate relatively small environmental effects. Therefore, mature weight at a constant degree of fatness is a convenient measure of size. There may be less variability of maturing rate, independent of size, than for size (31). However, US dairy breeds are probably relatively fast maturing in relation to their mature size (31), but there are few data to confirm this observation. One study indicated that Holsteins were relatively early maturing compared to Jersey and three beef breeds (52, 53). Rate of gain and degree of fatness of dairy steers can be expected to be closely proportional to mature size of the breed similar to the relationship expected for beef breeds. Further, if dairy and beef breeds of the same mature size were available and evaluated as feedlot steers, as indicated from the literature by extrapolation (8, 23, 48), similar rates of gain and amounts of total body fat (but not fat distribution) would be expected from the breeds at similar ages.

Dressing percent for dairy breeds is generally lower than for beef breeds, and if comparisons are on a liveweight basis, this difference should be taken into account. Because high yields of
milk require large intakes of feed of high energy density, dairy breeds probably have had positive selection differentials for capacity of the gastrointestinal tract (12, 33, 58).

Feed efficiency often is used to refer to O/I or its reciprocal such as feed or dry matter required per unit of gain. Net efficiency may refer to net energy stored per unit of metabolizable energy above maintenance. Variability of these ratios among young growing cattle of the same age and sex and treated alike is primarily a function of maintenance requirements and rate and composition of gain. In turn, most of the variability of maintenance requirements results from differences of body size and metabolic rate. Rate of gain is highly correlated with feed consumption (41), and body composition is correlated with stage of maturity (10). Again, it is difficult to compare differences of feed efficiency between breeds of cattle fed for equal lengths of time or fed to equal weights (73). If dairy and beef breeds are compared on equal weights and gains, the literature indicates that compared to British beef breeds (principally Hereford and Angus), dairy breeds (principally Holstein): 1) require 5 to 10% higher feed energy for maintenance (79), 2) convert feed energy to carcass energy 10 to 25% less efficiently (34), 3) convert feed energy to protein gain about equally or slightly less efficiently (34), and 4) convert feed energy above maintenance requirements to stored energy 10 to 25% less efficiently (34, 54, 55).

There appears to be only small O/I interactions of dairy and beef breeds with energy or protein concentration of the ration within moderate ranges (35, 58). One reason for the reported difference of net efficiency of stored energy above maintenance apparently has been due to greater fat deposition by the British beef breeds (34, 54, 55). These differences are in the same direction but may be smaller for the large, continental beef breeds (35). The British beef breeds in the US have evolved in recent years toward a larger size (taller and heavier), at least in many (probably the majority) herds, so that within breed variability has increased. Because of this variability and inherent problems of representative sampling of breeds, the results of breed comparison studies must be interpreted cautiously.

Production efficiency for Phase 1 (reproduction), or cow-calf production, is largely a function of maintenance requirements, milk production, and net lifetime fertility of the cows. The preweaning growth potential of calves is also a factor. The effect of maturing rate of heifers and longevity is part of net lifetime fertility (calves weaned per year of life). Again, clear comparisons are difficult because of inherently confounded effects.

Maintenance requirements of cows in the same herd are largely a function of size and physiological status (pregnancy, lactation, and age). There is a residual difference similar to the difference between beef and dairy breeds of growing cattle cited earlier. Dairy cows apparently have maintenance requirements about 10 to 20% higher than British beef breeds (68, 69, 78). No research indicating an interaction was found, but it seems reasonable to assume that because dairy cows tend to have less outside fat cover, this difference would tend to be greater in cold climates.

The general effect of body condition, reflecting nutrition, on postpartum interval, typified by thin cows requiring a longer interval to initiate postpartum cycling, is documented for beef cattle (88, 89, 90). The general effect of milk yield on calving interval in dairy cattle, even if fed ad libitum, is that higher producing cows tend to require a longer interval to initiate postpartum cycling (11, 72). It is not surprising that cows of dairy breeds tend to wean heavier calves but also tend to have longer postpartum intervals or smaller calf crop percentages when subjected to the nutritional stresses customary in beef cow management; however, dairy heifers tend to have higher conception rates than beef breeds treated similarly (87). These results indicate that the nutritional stress of milk production is involved in causing a longer interval in dairy cows. Earlier weaning and higher nutrition would be expected to reduce calving interval at least to that of beef breeds. These observations indicate a positive (undesired) phenotypic correlation between milk yield and postpartum interval that is due to the net effect of a positive environmental component and a negative genetic component. The cause and effect relationship between breeding values (BV) for milk yield and fertility is a basic question with important implications for selecting beef breed cows for optimal (moderate) milk production (36).

Dystocia is largely a function of size of cow
and size of calf (9, 43, 61). Especially when an objective of a beef herd is to have a cow produce a calf with a larger size potential than that of the cow, calving problems become a major concern. Dairy breeds vary considerably in incidence of dystocia, but there is little indication that differences between dairy and beef breeds not associated with size are important (74). A possible exception is easy calving ability of the Jersey cow relative to her size.

**BEEF AS A DAIRY HERD BY-PRODUCT**

Dairy breeds provide a substantial amount of beef through cull cows. Slaughter cattle records do not classify dairy cattle separately, but an estimate can be obtained by utilizing the dairy versus beef cattle numbers (82). About 22% of the cows in the US are classified as dairy and about 19% of the slaughter cattle are cows; therefore, an estimate is that about 4% of the beef produced in the US is from dairy cows. One estimate places dairy steers as 15 to 20% of steer and heifer slaughter cattle (59). There is little, if any, concern about differences between characteristics of cow beef from dairy and beef breeds. Dressing percent and ratio of muscle to bone from dairy breed cows can be expected to be lower, and prices are discounted accordingly. Larger carcasses, especially if deboned, have a lower processing cost per unit weight; therefore, cull cows from the larger dairy breeds have a positive price increment. Characteristics of dairy breed steers were reviewed earlier.

The question arises as to whether net income from dairy herds would be enhanced if dairy cattle selection included pressure for beef characters. Characters that might be considered for direct selection pressure based on comparisons with beef breeds are feed conversion, dressing percent, fat distribution, carcass cutout, and size or growth rate (3, 44). Growth rate is slightly positively correlated with milk yield, and both are related to size (49, 50). It is doubtful whether dairy breeders should tamper with reducing the capacity of the gastrointestinal tract, the major variable of dressing percent. The remaining characters are probably genetically correlated with milk production via physiological mechanisms such as those related to metabolic rate and mobilization of fat and protein stores (12, 33). Hanset (37) concluded in a review of selection for dairy and beef type that "the correlation (is) negative between width measurements and milk yield" (page 390), and that one reason for lower milk yield in European Black-and-White cattle was because of selection for "more compact type" (page 390).

If correlations between beef characters and milk production are negative, even if the relationships are low, the effects of selection to improve beef characters, combined with diverting some amount of selection pressure away from milk production, could be counter-productive, depending on the relative prices of cattle and milk. The medium range future for beef cattle prices (51) does not indicate that a shift toward beef emphasis would enhance net income from dairies.

The milk/beef production model of most European Common Market (EEC) countries places much more emphasis on the dual role of cattle herds than in the US. About 80% of the beef produced in Europe is from dairy herds (26), and the ratio of beef to milk prices was about 40% higher (6.08 vs. 4.38) in EEC than in the US during 1981 (5, 30, 83, 84). Estimates indicate that food energy produced by dairy herds (milk plus beef) is more efficient (as much as two times) than energy produced by beef herds (1, 76). In the Netherlands the aim of cattle breeding has been "defined as selecting the most profitable cow for a balanced series of production (milk and beef) and management traits", and "beef production capacity (growth rate, muscling) is taken into account in selection" (60, page 306). However, more recent trends indicate an increased interest in EEC countries of testing and importing North American Holstein and Brown Swiss and a trend toward emphasizing milk similar to that in the US (26, 39, 42). Estimates of replacement heifers sired by imported semen ranged from 30 to 60% for various EEC countries (26). Martin (48) concluded at the 1971 Dairy-Beef Symposium that dairy breed selection in the US should continue to be toward milk production. Except for broadening selection criteria from milk production to a more comprehensive evaluation of dairy production, including management characters, there appears to be little justification based on the present state of knowledge and the current ratio of beef to milk prices of 4.38 to suggest any dairy cattle selection in the US should be shifted toward beef characters. For the EEC to maintain their beef production as
dairy herd numbers stabilize, beef herd numbers diminish, and dairy production shifts toward the US pattern, Cunningham (26) recommended, among other measures, “development of beef selection in dairy breeds” (page 168). Also, Allen (2) and Allen et al. (3) recommended “clarification of breeding objectives” (page 124) and “dual testing schemes for milk and beef...which concentrate on carcass quality” (page 125).

DAIRY GENES IN BEEF HERDS

Dairy cattle genes almost certainly always have been in US beef cattle herds. The establishment of Land-Grant colleges by the Morrill Act in 1862 led to teaching and extension programs of grading up “scrub” cattle toward straightbred beef breeds. Performance testing of beef cattle was initiated in the 1940’s and had gained modest acceptance when Performance Registry International (PRI) and Beef Cattle Improvement Associations (BCIA) were initiated in 1955 and was well established by 1968 when Beef Improvement Federation (BIF) was formed (6). Documentation of heterosis among crosses of beef breeds began during the 1950’s (21). Performance testing programs similar to the Dairy Herd Improvement Association (DHIA) program provided an objective method for evaluating growth rate and later carcass and meat characteristics. The large dairy breeds, as well as the Charolais, performed well in these gain tests (22). Dairy gene migration into beef herds was initiated during the 1960’s and 1970’s on a “respectable” basis. The flood of imports of “exotic” breeds, most from continental Europe and some of which were dual purpose, gave further impetus to a trend of introducing different breeds into beef herds. The source of dairy breed genes has been both paternal and maternal, and the migration has been almost entirely via crossbreeding. For example, some Jersey herds bred cows to Angus to obtain a more valuable sale calf for beef purposes; however, Angus heifers have been bred to Jersey to reduce calving difficulties. The heifers from these crosses performed well as cows and a ready market developed (29). The large dairy breeds also have been introduced via both male and female sources.

The objectives of crossbreeding with dairy breeds in beef herds are: 1) to obtain additive (blending) effects of dairy breeds (maternal, Phase 1 traits, early maturing, milk yield, size or paternal, Phase 2 traits, growth rate); 2) to create and utilize hybrid vigor; 3) to exploit complementarity; and 4) to take advantage of a local economic opportunity. Characters that provide incentives for crossbreeding beef and dairy cattle are body size, (both large and small), milk yield, maturing rate, leanness, fertility, calving ease, and gastrointestinal capacity.

Averaging breeding values (BV) for milk yield of dairy and beef breeds has a dramatic effect by increasing weaning weight but, at the same time, it may place nutritional stress on the cow sufficient to suppress initiation of postpartum cycling until after weaning (45, 87). Averaging BV’s for body size of the large dairy breeds to enhance growth potential of smaller beef breeds, or at least not to reduce that potential while increasing milking ability, has been utilized with both British and continental European beef breeds. Introduction of the exotics was mainly through semen, and cows in dairies were a convenient resource to exploit; thus, crossbreeding, especially with the large dairy breeds, increased temporarily. Averaging the BV for size for smaller dairy breeds has been utilized to decrease maintenance requirements and increase milking ability of the cow herd and, for the Jersey, to retain or enhance calving ease. Also, dairy crosses tend to be younger at puberty because of a greater relative maturing rate (52, 53).

At the same time that beef cattle breeders learned that growing and milking abilities could be enhanced by crossing with appropriate dairy breeds without seriously compromising carcass or beef traits, hybrid vigor for beef production characters also was becoming more widely recognized (21, 25, 36, 45). It appears that about the same heterosis can be expected for crosses among dairy and European beef breeds as among European beef breeds and about the same heterosis for crosses among dairy and Zebu breeds (about twice the heterosis of European crosses) as among Zebu and European beef breeds (32, 45, 47, 52, 53).

Complementarity has been defined as the difference of herd productivity (O/I) of one cross over another cross separate from average breed and heterotic effects (17). The dairy breeds are useful for exploiting complementarity especially in the Phase 1 (cow-calf) component.
because of their maternal traits. As an example, the crossbreeding experiment of Ellison et al. (29) was designed to utilize complementarity and compared performance of Jersey × Angus F1 cows (AJ) bred to Charolais (C) and Hereford (H) sires to that of purebred Herefords. The average AJ cow produced 6-mo-old calves that were 66% of their dams average weight (310 kg) vs. 40% for the H cows (494 kg). The pre- and postweaning feed (total for 12 mo) consumed by cows per kilogram of calf weaned was 6.57 kg for the AJ cows and 7.66 kg for the H cows. The feed consumed by the calves per kilogram of gain to 12 mo was 5.49 kg for the AJ and 5.80 kg for the H, and the average 12 mo calf weights were 327 and 328 kg. A kilogram of liveweight sale calf required 10.4% less feed from the AJ herd than the H herd.

Crossbred heifers as by-products of dairy herds or from beef heifers bred to dairy bulls have been used in beef herds because they were priced lower than straight beef heifers. Likewise, crossbreds produced in dairy herds, especially as by-products of a grading up program to the exotics, have been used by beef herds because of attractive prices. These experiences with "economy" models introduced many dairy genes into beef herds and, perhaps more importantly, have been demonstrations that resulted in continued acceptance and a stronger market for dairy-beef crosses, at least for special purposes.

There are a few beef synthetics incorporating dairy breed genes (e.g. CharSwiss, Hays Converter, and Farmers Hybrid Lines) that have not been documented publicly and a few at research stations (e.g., Meat Animal Research Center MARC I, which includes one-fourth Brown Swiss).

CONCLUSIONS

The percentage of US slaughter cattle that carry genes of dairy breeds is probably 20 to 25%. The per capita beef consumption and fractions going into block and manufacturing beef have tended to stabilize along with beef prices (51). There is no apparent trend toward any substantial changes in the near future.

As young slaughter cattle per se, dairy breeds have some disadvantage. If cattle are compared on an equal body composition basis, many differences tend to diminish; important remaining differences are that dairy breeds require at least 10% more feed/gain to finish, and dressing percent, ratio of muscle to bone, and some cutout characteristics are lower. Therefore, lower prices are justified for dairy breed feeder and slaughter steers. Palatability characteristics of dairy beef are comparable to beef breeds.

In beef herds, dairy cows may provide BV's for desired large or small size and high milk yield, but maintenance requirements are about 10% higher; also, rebreeding while in a "milked down" condition is a problem, and enlarged teats and mastitis occur at higher rates. It is unlikely that dairy breed cows will be used extensively in beef herds. Cull dairy heifers and cows may be utilized more for specialty crossbreeding or production such as suckling multiple calves. If sexed semen becomes feasible, the use of cull females will be greatly enhanced; e.g., 400 to 450 kg crossbred weaning calves could be produced consistently.

The major question that arises for dairy cattle breeders appears to be whether any selection pressure should be diverted from dairy characters to beef characters, and if so, in what direction should it be applied. Recommendations have been made for EEC countries emphasizing the need to improve ratio of muscle to bone or carcass cutout (4, 26, 27). For US dairy breeders, there appears to be sufficient negatively correlated effects related to dairy production compared to benefits related to beef production (especially with a comparatively low ratio of beef to milk prices) to support a recommendation not to shift selection emphasis to increase muscle/bone or gain/feed. Increased selection emphasis on calving ease would reduce problems associated with breeding dairy cows to large, muscular beef breed sires and also would be beneficial for straight dairy breeding. This and other characters of dual purpose benefit that do not have adverse correlated effects should be considered for incorporation in dairy cattle selection criteria.

Generation intervals of cattle are long, and we should keep attuned closely to trends, such as those occurring in Europe, to anticipate needed changes. For the longer term future, we should consider the possibility of changes such as an increasing importance of beef as a dairy by-product, increasing use of dairy cull heifers as beef cows, and breeding dairy cows to beef
breed sires. Changes such as these would shift economic values and may justify placing selection emphasis on dairy breeds to increase muscle/bone and gain/feed and to decrease teat and udder problems. These characters appear to be correlated with milk production and, therefore, raise major selection concerns. Research is needed to quantify more completely phenotypic and genetic correlations between dairy and beef characters, to explicate further the physiological mechanisms mediating these correlations, and to clarify the selection and economic issues presently important in the EEC that may become more important in the US within the next few cattle generations.

REFERENCES


28 Dikeman, M. E., R. A. Merkel, and W. T. Magee. 1977. Effects of beef-type on bone, fat trim and


