OBJECTIVES AND INFORMATION IN A GLOBAL MARKET

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SUMMARY

Linear selection indexes are a generally effective means of achieving a breeding objective, while constrained indexes seem unnecessary and can be harmful. Customised indexes and mating programs often offer little technical benefit, can occasionally be detrimental, but have substantial extension and marketing benefits. The past 10 years have seen considerable advances in our understanding of the theory of deriving economic weights. But claims that a generalised framework have been achieved, leave several unresolved problems and have not received complete acceptance. In determining a breeding objective, overseas sales of genetic material should generally play a minor role. In some instances, sale of genetic improvement overseas may reduce domestic profits from improvement in production efficiency. For genetic parameters and genetic comparisons of breeds and lines, the published literature provides a wealth of often untapped information. A great deal of expense can be saved, and often more accurate estimates obtained, by using this literature rather than setting up specific trials.

INTRODUCTION

Glossy hand-outs, a firm handshake and sharp marketing may bring some success, but sustainable business is built on having the right product at the right price. Thus, a key question for marketers of livestock genetics, is how to produce the right product. The corollary for purchasers is how to choose the right product and where to find it.

This paper deals with the two issues of how to define the direction of genetic improvement and where to find the information necessary for informed decisions. It deals with the science of animal breeding, but remaining controversies leave some room for art.

OBJECTIVE DEFINITIONS, INDEXES AND MATING PROGRAMS.

It is useful to distinguish between the breeding objective, aggregate genotype and selection criterion, since these terms are important and often confused.

The breeding objective is defined as the overall goal of a breeding program. From an economic perspective, there have been discussions over whether this goal should be maximum profit or, as argued by Dickerson (1970, 1978), maximum economic efficiency, defined as the ratio of product value to product cost. The latter is appealing from the consumers perspective, and in an altruistic society should be the goal of improvement. But in reality those in the business of genetic improvement are interested in profit. Unless maximum efficiency equates with maximum profit (which is unlikely in practice), economic efficiency will not be the goal.

The aggregate genotype is a function of genetic traits which defines the breeding objective. The selection criterion is a function of observations upon which animals are ranked and the best selected for breeding. For selection within breeds or lines, the most common selection criterion is a linear selection index (Hazel 1943) which maximises response of a linear aggregate genotype. Although, non-linear indexes for non-linear aggregate genotypes can be constructed (Wilton et al. 1968), and theoretical problems of ignoring non-linearity have been discussed (eg Goddard 1983), there has been no demonstration that linear indexes are anything other than highly efficient for real life situations.

Constrained and desired gains indexes, which impose restrictions on the genetic change of one or more traits, have been widely discussed (see Brascamp 1982 for methodologies). The techniques of achieving constrained indexes have been of much academic interest. However, a good argument for using them in practice is lacking in the literature. Gibson and Kennedy (1990) argued that use of a constrained index often implied unrealistic economic weights and that a normal index could always be found to do a better job. They concluded that constrained indexes should be avoided in economic selection programs.

While conceptually straightforward, construction of selection indexes requires a high degree of technical expertise. Consequently, indexes are generally prepared by those with technical training as a service to the industry. A single index is often recommended for a given breed, since few breeds are sufficiently sub-divided into separate lines to allow more than one direction of genetic change with the prospect of making substantial progress. This view has recently been taken in Canada and worldwide for indexes ranking dairy bulls for selection (Gibson 1991; Gibson et al. 1992).

Customised indexes and mating programs are also gaining in popularity as a service to breeding industries world-wide. Such services can be useful where individual breeding operations are sufficiently large to be able to make independent genetic progress and exploit particular market niches or production environments. In more homogenised breeds and species, such as dairy cattle and those beef breeds made up of many small breeding operations, the economic value of such programs is doubtful. Often, such programs allow ad-hoc definitions of economic inputs, substantial errors in which can cause inefficiencies in index definition. Corrective mating routines are also common options, despite the general absence of theoretical or practical demonstration that they are of economic value. Inclusion of these options can range from the cosmetic to the catastrophic. Unfortunately, the increasing tendency to wrap mating programs in proprietary secrecy, often precludes independent assessment of their scientific validity and economic utility. However, well constructed customised indexes and mating programs can be effective extension tools, bringing on-farm the information necessary for effective economic breeding decisions.

DEFINING ECONOMIC VALUES

A common approach to defining economic values of traits to be improved is to construct a profit equation. This is a function of genetic, management, physical and economic inputs, and can range from the relatively simple to the highly complex. The economic weights used in a linear aggregate genotype are then the partial derivatives of profit with respect to each of the genetic traits in turn. Moav (1973) showed that such profit equations yield different relative economic weights when evaluated from different perspectives in the market. This is disturbing since genetically improved animals ultimately serve all levels of the market. Brascamp et al. (1985) showed that these differences disappeared for zero profit equations, in which normal profit at every level in the industry is included as a necessary cost of production. This is an expected outcome in freely competitive markets with full information. But, how often this applies in livestock industries is difficult to judge.

Smith, James and Brascamp (1986) argued that being a relatively slow but cumulative process, animal breeding has a long-term perspective. Since fixed costs are nearly always a short-term economic phenomenon, they should therefore be considered as variable costs in economic evaluation for genetic improvement. Similarly, breeding should not attempt to make up for sub-optimum management, since subsequent improvements in management would largely negate genetic improvements. They thus argued that improvements in output per enterprise as a result of genetic change should be discounted against improvements made by other means. Another argument would be that markets for most agricultural products in developed countries are saturated, hence genetic increases in economic output per animal would not lead to increased sales. Thus, the number of animals would have to be reduced in proportion to the increase in output per animal. Similar arguments were developed for economic inputs and profits.

Rescaling economic weights to account for these various constraints leads to the same relative economic weights in all cases. Furthermore, these economic weights are proportional to the rate of cha nge in the economic efficiency ratio (returns/costs) with respect to change in the genetic trait. This agrees with Dickerson's approach (Dickerson 1970, 1978). However, when considering economic outputs, the approach assumes that the market is perfectly matched to the production of different outputs, both before and after genetic improvement. It does not recognise the possibility that there is a market for extra output of one product, which is not currently fulfilled because a saturated market for other products makes production uneconomic. Similar arguments apply to constraints on economic inputs.

Gibson (1989) and van Arendonk and Brascamp (1990) derived economic weights for traits operating under quota systems. If the quota correctly reflects opportunities for marketing different products, then such weights would promote optimum economic genetic change for the farmer and the market as a whole. If not, economic weights scaled to quotas can produce distorted genetic change, inappropriate for the market as a whole, but optimum for the farmer, provided that the quota has long-term stability. However, the assumption of long-term stability of quotas is doubtful if the quota does not accurately reflect market demands for products.

McArthur (1987) criticised the rescaling approaches of Smith et al. (1986), and, by implication, those of Gibson (1989) and van Arendonk and Brascamp (1990), since they ignored reoptimisation of the production enterprise after genetic change. Following McArthur's lead, Amer and Fox (1992) formulated his criticism in terms of neo-classical production theory. This theory is attractive, though there is concern that the basis of production theory may be centred on short-term constraints. If so, these constraints will have to be carefully evaluated before applying the theory to animal breeding problems. Amer and Fox (1992) do, however, provide a framework which should allow the validity of rescaling approaches to be evaluated. An important question is whether or not reoptimisation of production is always a second order effect to genetic change and can therefore be ignored in practice.

THE INFLUENCE OF THE INTERNATIONAL MARKET

Breeding objectives are usually defined in relation to local conditions. International sales of genetic material have usually resulted as a side effect of successful local improvement programs (or simply the fortuitous possession of useful genetic material). With an increasingly global trade in livestock genetic material, should breeding objectives be more global in outlook?

The answer will lie in where most of the economic benefits of a genetic improvement program are likely to be recouped. As an example, consider the performance of Semex Canada as a notable success in the genetic export business. Semex operates as a cooperative of the AI organisations of Canada, which are themselves largely cooperatives of dairy farmers. In 1991 Semex reported foreign sales of $30m Canadian. For arguments sake, assume that at least half of that sum would be taken up in production, shipping and marketing costs, leaving a net profit of something less than $15m.

Current genetic trends for milk yield in the Canadian cow population (mainly Holsteins) are about 100kg/yr (Jacques Chesnais, personal communication). Our own work (Gibson, Graham and Burnside 1992) estimates the net profit from improved production, after allowing for costs and quotas, to be at least .35 of returns, which are currently about $.5 per kg. With 1.2m cows, this annual genetic improvement is worth 100*.5*.35*1.2*106 = $21*106. Since genetic improvement is cumulative, these returns are also recouped in subsequent years. With an inflation free discount rate of 5%, the cumulate net return over 20 years from one year of genetic improvement is worth ((1-(1.05)-20)/.05)*21*106 = 12.46*20*106 = $261.7m. Thus, the investment that leads to one year of genetic improvement in Canadian dairy cattle generates $261.7m *of net returns in the Canadian population and perhaps $15m net profit in foreign sales.*

Although these figures are approximate, there can be no doubt that the breeding objectives should be firmly focused on the home market. In this type of cooperative improvement program, successful foreign sales are the consequence of being successful in the home market. While it will be important to monitor the needs of other countries, substantive changes in the selection criterion at home to meet these foreign needs will likely result in less total profit to the domestic industry. However, there will be occasions where criterion can be altered with little effect on the genetic change, but substantial effects on perception of the index. As an example, for Canadian Holsteins, altering a selection index from giving 1:1 to 1:6 weighting on fat:protein production gives a clear perception of moving toward the "protein cow" while having less than 2% effect on economic response (Gibson et al. 1992; Gibson and Dekkers, in preparation).

Only where genetic improvement can be made in small independent operations (eg poultry and swine breeding companies, and perhaps some large sheep and very large beef operations), might it be feasible to include foreign sales in the breeding objective. The requirement would be that a large proportion of net income would have to be expected from foreign sales. It is probably unlikely that this would occur often or that it would be predictable in advance.

THE EFFECT OF FOREIGN SALES

Clearly, businesses that sell breeding stock exclusively to producers can build a sustainable market for their product. But with sheep, beef and dairy cattle, exported genetic material enters the client's breeding program. The more successful the export, the more rapidly the client country catches up to exporter's genetic level and thus reduces the advantage of further imports. It may well be that it is not economically viable for one country to run its own breeding program when another is doing better and is willing to provide cost-effective exports. But, convincing client countries of this has proved difficult. Thus the question of sustainability of sales in the foreign market is important, if making decisions about whether to target breeding objectives to foreign sales.

Amer and Fox (1992) raise another problem with foreign sales. If one group (country) were able to genetically improve production, and they form a relatively small proportion of the total (global) market for a particular product, then all the benefits of genetic improvement would remain with the group. This arises because their improvements in efficiency would have almost no effect on market prices. Indeed, by improving efficiency and lowering their prices slightly it may be possible to increase sales and recoup benefits in excess of those predicted by traditional profit equations. All these benefits to producers would be lost if aggressive foreign sales of genetically improved stock spread genetic improvement to other countries, eventually forcing down prices (which would benefit consumers). Short-term gains from genetic sales would be at the expense of passing up large long-term gains in profit from production. With the potential of the GATT to produce a single global dairy market, it is interesting to speculate whether the massive export of North American Holstein genetics will ultimately cost the North American dairy industry more in lost world market share of dairy products than ever they gained in foreign genetic sales.

SOURCES OF INFORMATION

In moving from breeding objectives to selection criteria, information is needed; 1/ On the interactions of genetic change with management, physical and economic factors, and how this affects profit; 2/ On genetic and phenotypic parameters in order to construct selection indexes; 3/ For the purchaser of genetic material, on the genetic merit of stock from alternative sources.

Category 1/ is not dealt with here, except to note that economic weights must be based on genetic not phenotypic relationships with profit (a common error in practice). Also, economic weights can be found by construction of profit equations, or from bio-economic modelling, using either deterministic relationships (eg Tess et al. 1983), Linear Programming (eg Wilton 1980), Dynamic Programming (van Arendonk 1987) or based on neo-classical production theory (Amer and Fox 1992).

There is a tendency to believe that genetic and phenotypic parameters must be collected from the population to be improved. While it is true that the parameters used should apply to the population, it does not follow that using estimates from the population is the best way to achieve this. There is considerable anecdotal evidence that estimates of phenotypic and genetic parameters, particularly the latter, have much higher errors than current theory would predict, though this does not seem to have been formally documented. In our own experience, 7 estimates (not all published) of h2 for milk yield of Canadian Holsteins, all based on overlapping large data sets collected within the last few years, analysed with several models, gave heritabilities ranging from 0.2 to 0.5. Theoretically, each estimate had a small standard error. Thus, either h2 varies substantially and essentially unpredictably within populations over time, or our estimation procedures give very low estimates of true prediction errors. Either conclusion suggests that literature averages might give substantially better estimates of parameters than those estimated for a particular population.

In an on-going study (Koots, Gibson and Wilton 1992) literature estimates of population parameters for 71 traits of beef cattle have been compiled. The amount of existing information for some traits is substantial. For example, there were 239, 184, 172 and 154 published estimates of h2 for weaning weight (direct), post-weaning gain, birth weight (direct) and yearling weight. These data are being analysed for systematic effects of breed, environment and method of analysis. A few factors have been found to significantly affect estimates of h2, though little of the variation between estimates is accounted for. A surprising result (i.e. contrary to current belief), was the absence of a difference between test-station and field data in h2 for growth traits. For most traits, the observed variance between estimates, after accounting for significant effects on h2, was about four-times higher than the predicted theoretical variance. Again, this suggests that for many traits, use of means of published parameter estimates, perhaps adjusted for particular effects, would be a better policy than estimating parameters locally.

Similar arguments can be applied to choosing between different breeds or lines. Again, for many traits and breeds there are a wealth of published comparisons. Given the large experiments required to obtain accurate information in breed comparison work, a great deal of time, effort and expense could be saved by careful compilation of existing literature. A good example is provided by Amer, Kemp and Smith (1992) who combined data for a series of large breed comparison studies in North America over the past 20 years. Many of the differences in results between trials could ultimately be explained by differences in treatments, methods of recording, definition of traits and genetic trends. The outcome was a consistent set of results which could be used to make breed selection decisions. With the exception of growth rate traits, these results were also consistent with other studies and surveys (Amer, personal communication). And between the various studies, it was possible to identify the key traits to an economic comparison for which information is not available, which should help in the design of cost-effective future trials.

CONCLUSIONS

While controversies remain, the principles of defining breeding objectives are well understood, and relatively simple selection criteria can be found to effect genetic change. Overseas genetic sales are unlikely to influence breeding objectives, but may affect the value of genetic improvement. While the temptation is to design specific trials to collect genetic information, much time and expense can often be saved by first accessing information available in the published literature.

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