EXPERIENCE WITH ECONOMIC WEIGHTS

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SUMMARY

We examine the use of economic values in the context of design and implementation of livestock improvement programs. Breeding objectives can be conceived in different ways by geneticists, economists and breeders. Thus, we discuss the development of breeding objectives when explicit economic values are described from a pre-defined aggregate genotype, for breeding objectives with target levels for different traits, and combinations of these. Genetic improvement must evolve to guiding the design of integrated breeding programs that maximize the rate of economic improvement of livestock production and not just the accuracy of genetic evaluation.

INTRODUCTION

Genetic evaluation of most livestock species is accomplished through services processing pedigree information and performance records. The outcome is a series of Estimated Breeding Values (EBVs) [or of Expected Progeny Differences (EPDs)]. Given a number of candidates for selection, all with EBVs for the relevant performance traits, objectively deciding which animals to use remains difficult. These genetic evaluation procedures should be considered a means to an end, and not the end itself. The desired end is an improved economy of producing consumable livestock products for the benefit of all consumers. A frequently weak point of genetic evaluation concerns the definition of a basis for selection (breeding objective) that provides economic direction for the process.

The topic 'Experience with economic values' may be approached from a number of different perspectives. In this paper we chose to examine the area from the point of view of usefulness and relevance of economic values in the broad context of design and implementation of genetic improvement programs, especially in the extensive livestock industries. Reviews of alternative methodologies used in the derivation of economic values have been given elsewhere (e.g. Pirchner, 1993; Wickham, 1993; Harris, 1993; Amer, 1994 - these Proceedings; Harris and Newman, 1994) and are not dealt with here.

IDEAL MOTIVATION FOR GENETIC IMPROVEMENT

Figure 1 represents an assumed hierarchical structure of a livestock industry (adapted from Harris et al., 1984). The metaphor of a "pyramid" is used as an aid in conceptualizing the expansion of genetic improvements from elite herds or flocks to commercial herds or flocks through multiplication. Bichard (1971) used the term "dissemination" for this expansion. Figure 1 represents an ideal structure for the several classes of livestock. In such a structure improvement from genetic selection passes from the top tier or strata to the reproduction and growth phases of production herds or flocks and also influences the processing and consumption phases.

Seedstock producers (breeders in charge of elite herds or flocks at the apex of the pyramid), and their customers (commercial producers who produce food and (or) fibre) are in their respective businesses to make a profit. In turn, commercial producers' profits are influenced by consumers' demand for their products. The purchase of breeding stock involves a cost to the commercial producer, but it can have a positive influence on the system. It might reduce expenses, increase income, or both. The commercial producer will be motivated to pay more for breeding stock if given clear assurance that profit will increase as a consequence of these increased costs. By contrast, income generating products sold by seedstock producers are primarily breeding stock. Efforts to improve the value of that product (and thus the income received) are likely to add expenses for the seedstock

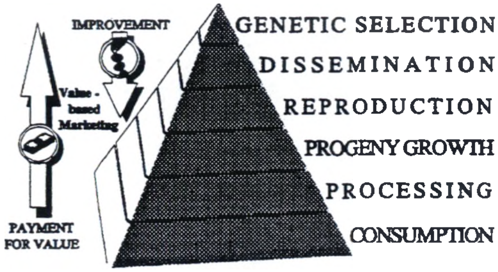

Figure 1 Dissemination structure of a livestock industry

producer for the extra labor of recording data, registration and computer charges, marketing of intact animals for slaughter, and so on. The seedstock producer will be motivated if given clear assurance that sufficiently greater income will occur as a consequence of these increased expenses. Selling more breeding stock at a higher price would provide the necessary motivation. However, for this to occur, breeders must accept the responsibility for developing the information their customers need to assess the added value of improved breeding stock accurately enough to increase payments for the breeding stock. Genetic evaluation within and across herds or flocks for several performance traits have taken the industries a long way towards such an arrangement. The remaining task could then simply consist of combining these EBVs into a single-valued measure of an animal's worth to the customer's profit objective. From this perspective the breeding objective (aggregate genotype) of the seedstock producer should reflect the breeding stocks' influence upon profit in the commercial producer's (customer's) herd or flock.

A formal definition of the breeding objective, culminating with the derivation of an economic value for each trait, would neatly fit the above idealized situation. In reality, a variety of circumstances can influence the relationship between the different industry segments described in figure 1, and affect the orderly flow of ideas and of economic benefit from top to bottom of the pyramid. In the sections that follow we discuss a number of such circumstances.

SUCCESSFUL MARKETING AS A SUBSTITUTE FOR GENETIC MERIT

There are instances in which the prices paid for stock from a particular source are grossly out of proportion with respect to the genetic merit of that stock. This is often the result of a successful stock preparation and marketing strategy, coupled sometimes with earlier economic and social achievements. Buyers of such stock succumb to the temptation of attempting to make similarly large profits in some not too distant future. When this happens, the value paid for breeding stock and the benefit passed on to the buyer bear little relation to the economic values derived by technical advisers. This type of serious distortion of values constitutes one of the undesirable features of a free market environment. The opposite phenomenon can, of course, also occur. Stock of high genetic merit can fetch lower than deserved prices due to poor or insufficient promotion. Those of us somehow associated with the livestock industries can no doubt cite specific cases in which the above referred to situation has occurred. Bendall and Bendall (1993), in a very interesting paper on how farmers interpret breeding objectives, comment on the problem in New Zealand.

If adequate genetic evaluation information were available for the stock in question, then economic values could be used to demonstrate the magnitude of the distortion in the price. This could constitute a useful educational exercise that could positively contribute towards achieving a greater understanding of logically designed and implemented genetic improvement programs.

DEVELOPING A LOGICAL BREEDING PROGRAM

General

It is generally accepted that a primary consideration in the development of a genetic improvement program is the definition of a breeding objective. Note, however that a 'breeding objective' may be conceived in different ways by different people. Geneticists and economists usually prefer defining it as an aggregate of breeding values for all traits influencing income and (or) expenses, with each breeding value weighted by an appropriately derived economic value. By contrast, others (breeders in particular) may prefer to think about the breeding objective in terms of a specific combination of target levels for different traits. While there would be almost unanimous agreement that maximizing profit is the aim, the former group focuses on it directly, whereas the latter hopes to improve profit, but by concentrating on traits to be improved by pre-determined amounts.

In this section we examine situations in which one or the other approach may be preferred.

Breeding objectives with explicit economic values

Once the livestock production system and the traits influencing income and (or) expense have been established, deriving economic values for each trait is often a relatively straightforward matter. The breeding objective becomes an aggregate of breeding values weighted by their respective economic values (Hazel, 1943; Henderson, 1963). Usually, selection indices are calculated in such a way that the correlation between the index and the breeding objective is maximized. Index values for different individuals have a precise meaning, and they can be used to assess the economic consequences of using the available selection candidates.

Economic breeding objectives defined in this way are ideally suited to examine the flow of benefits between segments of an industry (e.g., see figure 1). This approach has been used in performance recording and genetic evaluation services such as STAGES (U.S. pig industry; Stewart et al., 1990) and WOOLPLAN (Australian wool sheep; Ponzoni, 1987).

Note, however, that product prices and production costs have to be assumed for the definition of an economic breeding objective, and producers are well aware of their possible instability over time. Although conventional wisdom indicates that selection indices are 'robust' against deviations of prices and costs from the assumed values, it is our experience that possible price and cost variations create uncertainty among breeders and contribute to reduced acceptance of economic indices. The reasoning explaining the 'robustness' of selection indices is not always readily understood by breeders. We believe that lack of confidence in a measure of merit based on a fixed set of prices and costs, coupled with the inherent complexity of its calculation, are reasons behind the low (about 20 per cent) usage of the WOOLPLAN index by Australian Merino stud breeders responding to a survey (Singh, 1991/92). This perception is consistent with the conclusion drawn by Bendall and Bendall (1993), that in New Zealand, many farmers still base their selection decisions on visual appearance, rather than being prepared to accept a ram's index as a reliable predictor of genetic merit.

Alternatively, swine breeders in the US found indexes from STAGES acceptable as a measure of genetic merit because indexes have been used in test station situations for years (D.L. Harris, pers. comm.). However, concerns have been voiced about the fluctuation of costs and values over time, and even controversy over the idea that the emphasis of genetic evaluation schemes using breeding objectives do not agree with the breeders' preconceived notions. In the beef cattle industry, there are many breeds being used over numerous production and marketing systems. From this perspective, the development of 'customized' objectives allows flexibility of developing breeding objectives and selection indexes for individual breeders and their commercial customers (Barwick, 1993).

While it is true, as stated earlier, that selection indices are generally 'robust' against deviations from the assumed prices and production costs, there may be other assumptions that have a larger effect. With Merino sheep, it can be shown that the economic value of reproductive rate varies substantially depending on whether the feed resource is assumed to be fixed or variable (Ponzoni, 1988), and this can change not only the magnitude, but also the sign of predicted genetic change in some traits. We doubt whether there would be many producers in a position to thoroughly understand the nature and implications of these assumptions.

Amongst breeders using an economically derived breeding objective, we have often observed that they are tempted to try and alter their economic values in response to market fluctuations. This, of course, defies the usual warning that if you frequently change the objective you are unlikely to make much progress.

Breeding objectives with target levels for different traits

Another method of defining a breeding objective is by stating target production levels for the population in question, sometimes within a given time-frame (Atkins and Mortimer, 1990). This approach is akin to the 'desired gains' of Pesek and Baker (1969). Such targets are a statement of intent or objective. Producers probably have a greater affinity with this approach than with the economic objective. For example, a Merino breeder may conclude that given his (or her) perception of the future, the best course of action is to increase clean fleece weight by 0.5 kg, reduce fibre diameter by 1.0 micron and increase live weight by 2.0 kg, while maintaining reproductive rate at approximately current levels, and setting a time-frame of 10 years to achieve these targets. Dickerson et al., (1974) developed a selection index that put negative emphasis on birth weight as a strategy to reduce calving difficulty, while in theory having little effect on yearling weight. Whether these targets are achieved or not will depend on the breeder choosing an appropriate selection strategy.

There are instances in which there is no clear association between the direction of changes generally perceived and accepted as desirable, and the system of payment to the producer. The sheep meat industry in Australia provides an example of this type of problem. There have been difficulties in establishing a system under which producers are rewarded if they produce carcasses of greater merit. Under such circumstances using the economic approach can be troublesome, whereas the target level approach is more likely to be readily understood and accepted. Some have argued that the desired gains approaches may compromise the economic effectiveness of the index approach (e.g., Gibson and Kennedy, 1990). We believe that such approaches may be the best alternative when economic values are difficult to specify or are in risk of being erroneous.

LAMBPLAN, the Australian genetic evaluation and improvement system for the prime lamb industry, provides an interesting and successful example of the target level approach. Because of the difficulties outlined earlier, it is difficult to assign economic values to growth rate and to carcass attributes. However, without explicitly using economic values, LAMBPLAN offers six breeding objective options for terminal sire breeds, namely:

(i) High growth: to achieve the maximum increase in growth rate.

(ii) Growth 80: to achieve near maximum increase in growth with some reduction in fat.

(iii) Lean growth: to increase growth rate and reduce fat depth (at constant weight) in equal proportions.

(iv) Growth 80 + eye muscle area (EMA): to achieve near maximum increase in growth rate but hold fat depth and eye muscle size (at constant weight) constant.

(v) Lean growth + EMA: to achieve equal proportional improvements in growth rate, fat depth and eye muscle size (at constant weight).

(vi) 60:20:20: segments total gain (in genetic standard deviation units) between growth, fat depth, and EMA.

Target genetic changes for option (i) are + 10 kg live weight at 12 mo with no change in fat cover, whereas for option (iii) they are + 7.5 kg and - 3.0 mm for live weight and fat cover, respectively.

Bendall and Bendall (1993) mention that while some manufacturers prefer high bulk wool, this is not always reflected by market signals. The adoption of a target level approach could be worth considering in this situation.

It is our general impression that breeders feel more comfortable defining the breeding objective via target production levels, than via explicitly derived economic values. Using the target production level approach breeders more readily accept the relative emphasis to be placed on each trait, identifying themselves with the chosen objective. By contrast, there is relatively frequent reluctance to accept the economic values elegantly derived by scientists, even though they might have been carefully obtained, and might be very similar to the weightings arrived at by the breeder by other means.

Joint use of the economic and the target driven approaches

In practice, there are advantages in jointly using the economic and the target driven approaches, irrespective of whether the breeder's definition of the breeding objective was initially economically or target motivated.

When economic values are formally derived and used as the driving force in the breeding program it is always worthwhile examining the predicted genetic change for all important traits, after, say, 10 years of program conduct. By doing this, the breeder can see whether the accepted economic parameters will result in trait changes that are totally 'acceptable'. It could be that the breeder finds that some of the predicted changes are too small or too large for his (or her) perception of what the animals ought to look like in 10 years time.

'Checks' are also desirable when the breeding objective is derived using the target production level approach. The first check should, of course, be aimed at establishing whether the chosen target production levels are achievable within the constraints of structure and reproductive rate for the population in question. It could be that the breeder is too ambitious and that the combination of target production level for the various traits is not achievable. Secondly, when the target production approach is used (and target levels are achievable) the estimated breeding values have to be weighted in order to achieve the objective, and these weightings are 'implied (relative) economic values'. When this is done, it is worth checking whether the implied economic values are consistent with the present or with some anticipated future economic situation. For example, the relevance of fibre diameter variability in Australian Merino breeding objective has been recently the subject of considerable debate. It has been suggested that from the processing point of view, not only mean fibre diameter is important, but also the coefficient of variation of fibre diameter. One way of reducing the coefficient of variation of fibre diameter is by decreasing the standard deviation of fibre diameter while maintaining average fibre diameter unchanged. It can be shown that when this is done the implied economic value of the standard deviation of fibre diameter is overestimated by a factor of approximately ten with respect to that of average fibre diameter, based on what current economic information would suggest. Such a gross discrepancy between the two values would call for a serious re-examination of the breeding objective.

We support the notion advanced by Atkins and Mortimer (1990) that the utility of jointly using the economic and the target level approach is to make sure that the producer's view of what the production levels should be, is matched by the perspective of what the future prices and production costs will be. It would probably be wise to routinely check breeding objectives for a range of economic scenarios, irrespective of whether they were economic or target driven in the first place.

A special case - disease resistance

The presence of genetic variation in resistance to disease, coupled with increased consumer pressure against the use of drugs, is making genetic solutions to animal health problems increasingly attractive. The non-permanent effectiveness of chemical agents (due to development of resistance by the pathogen) further contributes to this interest.

When animals are individually treated against an illness, calculation of the corresponding economic value is relatively straightforward (e.g. see dairy cattle situation described by Eriksson and Solbu, 1993). There are instances, however, in which treatments are applied to groups of animals as a whole, thus leaving no between-animal variation in the cost of treatment. In such cases there would be no immediate economic gain resulting from response to selection against the disease. Piper and Barger (1988) and Carrick and Ponzoni (1991) identify and discuss this problem as it pertains to Australian Merino sheep.

In the Australian Merino derivation of economic values for the major production traits (i.e. clean fleece weight, fibre diameter, reproductive rate and live weight) is relatively straightforward. There are estimates of genetic parameters for resistance to internal parasites, but for the reasons outlined above, calculation of the economic value for that trait is not possible. Using the theory presented by Brascamp (1984), Woolaston and Piper (personal communication) develop a breeding objective in which economic values are used for the production traits listed earlier, whereas a desired gains approach is used for resistance to internal parasites. In this example, the breeding objective is partly defined using the economic approach, and partly defined using the target production level approach.

CONCLUDING REMARKS

The deliberations made in the present paper should not be perceived as undermining the value or as negating the need for continued rigorous work in the area of derivation of economic values. That work is not only of great practical value, but also, it contributes to a greater understanding of the dynamics of the industry in question. Economic values are essential in the calculation of the economic worth of breeding programs. In deriving economic values, one must first establish *all* traits influencing income and expense. This helps ensure the completeness of the breeding objective. With other, less systematic approaches it is easier to omit traits of some relevance, and this can have undesirable repercussions (e.g., Ponzoni, 1988; Newman et al., 1992). Work on economic values should proceed alongside the establishment of logical target production levels in breeding programs.

Performance recording and genetic evaluation services should be flexible, enabling the definition of breeding objectives in different ways, according to traits' suitability and to breeders' preferences. There will be many instances in which the most appropriate course of action does not necessarily involve explicit use of economic values.

It is our perception that until breeders are given clear guidance on the use of EBVs in a logical manner, much of the effort and funds spent in the development of expensive genetic evaluation systems will continue to be wasted, to a large extent due to a lack of breeding objectives. The development of software packages such as OBJECT (Atkins et al., 1994) for Australian Merino sheep is an example worth imitating. The package is simple enough to be useable with breeders, while at the same time it is rigorous enough that it closely approximates results that could be obtained by much more complex models.

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