COSTING FEED IN SELECTION: RECONCILING SOME DIFFERENCES IN APPROACH AND REVISITING ISSUES FOR BEEF CATTLE SELECTION

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INTRODUCTION

Opinions sometimes differ across species on the need to increase or decrease feed intake. A difference in selection emphasis on feed intake might be expected given the widely differing production systems and selection circumstances that can be encountered. Some of the difference in opinion may be due to the way the selection problem, and especially the breeding objective, is formulated. The long-standing issue of distinguishing selection criteria from breeding objective traits (James, 1986) may also be involved. Kennedy *et al.* (1993), and more recently van der Werf (2000), demonstrated how selection on residual feed intake, itself a linear function of criteria, statistically relates to selection on the component criteria. This paper focuses on highly related matters, but from the point of view of the breeding objective. A simplified example is used to illustrate how results for feed traits can differ as a consequence only of the way the breeding objective is formulated. Some other sources of differences and implications for the use of phenotypic modelling are then briefly examined and discussed in relation to beef cattle selection.

RECONCILING DIFFERENT APPROACHES TO THE SELECTION PROBLEM

Use of partial versus more complete breeding objectives. It is common to consider selection for a small number of traits in isolation from other economic traits, or together with valuing predicted changes in other traits. Table 1 illustrates the limitations in working with such partially formed breeding objectives, using a simplified example. In the example, the fully formed breeding objective includes two traits, a production and a feed trait. The result obtained with this formulation (i.e. number 1) is correct. The partially-formed breeding objectives include only one trait, with account taken of correlated change in the other trait in the economic value. Across the formulations shown, the trait economic values and index weightings resulting for the feed trait vary from negative through positive and yield very different estimates of trait change.

Species and production system differences affecting definition of feed traits. In addition to impacting on trait economic values, production system and management differences within and across species affect the definition of feed intake traits required for breeding objectives, and hence the genetic parameters that are appropriate. When forming the breeding objective the aim is to define traits under management that is ‘best’ for the production system addressed. In intensive systems, feed may be supplied *ad libitum*, or it may be controlled with other aspects of the environment.

Table 1. Breeding objectives, selection indexes[A] and trait gains for an example involving a production (P) and a feed intake (F) trait. Shown are breeding objectives where breeding values for P and F traits (G_F, G_P) are both included, where one (G_{F*} or G_{P*}) is included with change in the other accounted for only in the economic value, and where a residual trait[B] (G_{resP} or G_{resF}) is included.

Breeding objective			Index (I) weightings		Trait gain	
No.	Traits	Economic values[C]	$\hat{G}_P$	$\hat{G}_F$	ΔG_F per unit I	ΔG_F per s.d I
1	G_P, G_F	1.0, -0.5	1.0	-0.5	-0.118	-0.108
2	G_{F*}	0.049	0	0.049	20.4	1.0
3	G_{P*}	0.726	0.726	0	0.551	0.4
4	G_{F*}, G_{resP}	0.049, 1.0	as for 1.		as for 1.	
5	G_{P*}, G_{resF}	0.726, -0.5	as for 1.		as for 1.	

[A] Selection is assumed to be on the shown Index of EBVs ($\hat{G}_P$, $\hat{G}_F$) for P and F.

[B] Residual traits resP and resF are P and F, phenotypically adjusted for F and P, respectively

[C] Economic values shown apply to the respective breeding objective traits

Assumptions: Economic values for P, F: 1.0, -0.5 when both are in the breeding objective; heritabilities for P, F: both 0.3; genetic variance for P, F and their EBVs: all 1.0; EBV accuracies: both 1.0; genetic correlation P, F: 0.4; phenotypic correlation P, F: 0.55

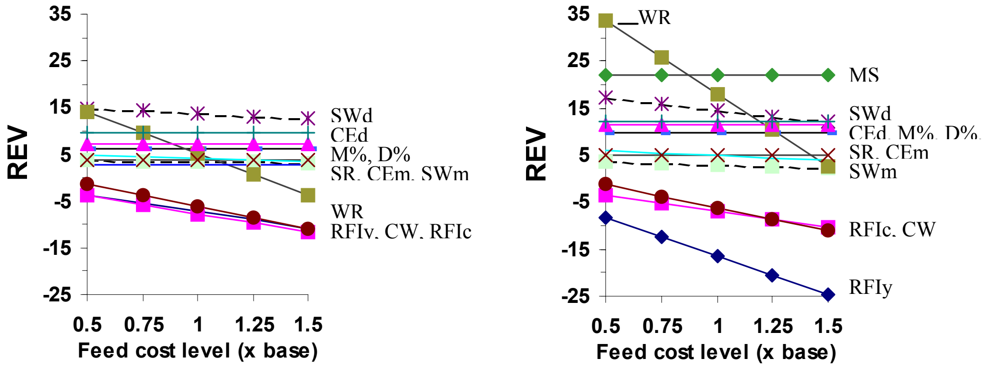
In either case, the conditions applying need to be part of the feed intake trait definition. If these conditions change between segments of a production system then, strictly, so also should the defined trait. In the extensive pasture based beef systems common in Australia, good management usually involves utilising available feed as completely as risk levels allow, aiming for growth rates of sale animals that are as fast as possible. Breeding females are commonly run on lesser quality feed. For these situations, for example, it may be reasonable to define feed intake of young animals under *ad libitum* feeding, and that for breeding females under more restricted feeding. Cow feed intake in most intensive dairy systems, by contrast, is likely to be defined under *ad libitum* feeding.

Encompassing correlated trait change in trait economic values. Valuing the phenotypic change that is associated with a trait by including it in the trait economic value is not equivalent to specifying both traits in the breeding objective (Table 1, breeding objectives 2,3 cf. 1). Breeding objective 2 represents the situation where the former approach is taken for feed intake, perhaps with a view to deciding whether its value is really positive or negative. Here it would lead to the incorrect conclusion that the trait economic value, associated index weighting, and change in the trait are all positive. Breeding objective 3 represents the situation where account has to be taken of associated feed costs, but there is perhaps little knowledge of genetic parameters for feed intake, including its association with production traits. Again it leads to incorrect results. Correct results for each of these circumstances are reproduced when appropriate residual traits are added to the breeding objective (Table 1). Koots and Gibson (1998) drew attention to the need for residual traits in this type of circumstance for a breeding objective that utilised calculations from a growth model.

Use of phenotypic models. 'Biological' (eg. Fowler *et al.*, 1976 ; Kanis and de Vries, 1992) and systems (Tess *et al*., 1983) modelling can be employed in selection, for example to help estimate economic impacts and to suggest selection criteria. It has also been suggested these models be used to define breeding objective traits (eg. Bourdon and Enns, 1998). The usual motivation for their use is to exploit knowledge existing at the phenotypic level, with its promise of insights into interactions, biological optima and limits to trait change. The use of such models can resemble statistical modelling, for example as occurs when a trait is phenotypically adjusted for other effects. Phenotypic adjustment of selection criteria poses no problem for selection indexes provided appropriate genetic parameters are used (Kennedy *et al*., 1993). However when the adjustment occurs in relation to traits of the breeding objective, or *in lieu* of the separate specification of a breeding objective trait, there is a risk of errors of the type shown in Table 1. This is overcome, as shown in Table 1, with appropriate inclusion of residual traits. In practice, when the modelling is at a detailed biological level it can be hard to decipher when and which residual traits are needed. Use of detailed biological modelling can thus make it more difficult to know when trait importance has been correctly counted.

SOME ISSUES REVISITED FOR BEEF CATTLE SELECTION

Cost of a unit of feed. The cost of a unit of feed can vary substantially between individual beef production businesses, at least across extensive pasture-based systems common in Australia. Differences arise from variation in, for example, the suitability of land for establishing pastures or producing fodder, in stock carrying capacity, and in the stocking rate employed. How feed is costed can also be an issue.



Domestic **Japanese**

Figure 1. Effect of feed cost level on trait importance in beef breeding objectives addressing production for Australian domestic and Japanese export markets. REVs are defined as the economic value of a genetic standard deviation of trait change. Traits are calving ease direct (d) and maternal (m) (CEd,m), residual feed intake (RFIy), sale liveweight (SWd,m), dressing percent (D%), carcass meat % (M%), fat depth (FD) and marbling score (MS) of calves, and residual feed intake (RFIc), weaning rate (WR), liveweight (CW) and survival rate (SR) of cows. The assumed 'base' feed cost is 1.63 and 1.15 c/MJ for young animals in Japanese and Domestic objectives respectively, and 1.15 c/MJ for cows.

Usual options include costing hay or concentrates purchased, land leased or agisted, or pasture, silage or fodder crop produced, or valuing lost profit from the reduction in stock numbers needed to offset a given feed requirement. Different methods can yield quite different feed cost estimates (Farquharson, 1993). Figure 1 illustrates how change in the assumed feed cost can substantially affect trait importance for breeding, for updates of two breeding objectives described by Barwick *et al.* (1999). The figure suggests that effort to improve feed cost assessment for individual breeder production systems could well be as important as efforts to improve other aspects of the modelling of selection problems.

Robustness of selection. Concern about the adequacy of knowledge of genetic relationships with feed intake has been a factor in encouraging studies of residual feed intake in beef cattle in Australia. The phenotypic adjustment that occurs in calculating residual feed intake makes that criterion relatively independent of growth at the genetic level in Australian data (Arthur *et al.*, 2001). This lessens the need for knowledge of genetic relationships between feed intake and growth. The need for information on genetic relationships with all other economic traits, however, remains the same for residual feed intake and for (unadjusted) feed intake.

Including residual feed intake in Indexes. Some consideration has been given to including residual feed intake EBVs in aggregate indexes for the Australian beef industry (Barwick *et al.*, 1999). The approach involves including residual feed intake traits for both young animals and cows in the breeding objective, together with valuing the change in feed requirement associated with other economic traits in their economic values. This approach is analogous to number 5 of Table 1. The changed feed requirement associated with traits is predicted from feeding standards. As more information on genetic relationships with feed intake becomes available the approach will be reappraised and consideration given to specifying unadjusted feed intake traits in the breeding objective.

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