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GENETIC PARAMETERS AND ECONOMIC VALUES OF TRAITS OTHER THAN PRODUCTION FOR DAIRY CATTLE

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SUMMARY

The New Zealand Dairy Board, as part of its bull progeny-testing programme, routinely collects farmer assessments of non-production traits. These data from 2 years were analysed to obtain estimates of heritabilities and genetic correlations for both the Friesian and Jersey breeds. Estimates of economic values were obtained using survival from first to second lactation as dependent variable in a linear model, with fat yield and scores for the non-production traits as independent variables. In combination, the estimated economic values and genetic parameters indicate that, apart from fat yield, the only other trait (amongst those measured) likely to substantially contribute to total genetic gain is shed temperament.

INTRODUCTION

The value of a dairy cow depends not only on the amount of milk she produces but also on a number of other characteristics which can influence the cost of her production. These traits include fertility, feed conversion efficiency, resistance to diseases, and a number of characteristics associated with milking many of which are very difficult to measure under normal farm management conditions.

If they are to be included as part of a breeding objective for large-scale genetic improvement programmes, they need to be measured, the measurements converted to meaningful indicators of genetic merit, and selection decisions made giving proper weight to each.

One way to measure some of these traits is a system of farmer reporting. This has been used for many years as the main method of collecting information on the progeny of bulls included in the New Zealand Dairy Board's testing programme. Initially, the questions were of the general form: Is this cow satisfactory for jaw, feet, udder, tendency to get mastitis, ease of milking, temperament, tendency to bloat?

Analyses conducted on these qualitative data produced estimates of heritability of 0 for jaws, feet and mastitis, and between 0.04 and 0.07 for udder, milking ease, temperament and bloat susceptibility (New Zealand Dairy Board, unpublished results). Subsequently, the method of reporting was modified to allow a wider range of farmer responses to each question. In addition, the farmers were asked to report on each cow twice, once in October and again in March. Results of analyses of the first 2 years using the changed procedures are contained in this paper.

Many traits are heritable, but because they are of no economic significance there is no justification for including them in a selection objective. For this reason it is very important to know the economic consequences of changes in any heritable trait. Traits such as ease of attaching milking machine cups (cups on), teat placement and udder shape are notoriously difficult to place economic values on. In this paper a method of estimating the economic values that farmers place on such traits is developed and the resulting values used to evaluate five alternative methods of selecting progeny-tested dairy bulls.

DATA

The New Zealand Dairy Board progeny tests its bulls in a selected group of approximately 400 herds. These herds are scattered throughout New Zealand and have been selected on the

TABLE 1: NUMBER AND PERCENTAGE OF COWS IN SAMPLE WITH RECORDED DETAILS

Combination of Details Recorded	*1st Calf 1975* No.	*1st Calf 1975* %	*1st Calf 1976* No.	*1st Calf 1976* %
October assessment (October TOP)	7457	86	7509	93
March assessment (March TOP)	6926	80	7437	92
1st-lactation production (1st lact.)	7694	89	7137	88
2nd-lactation production (2nd lact.)	4901	56	4423	55
October TOP + March TOP	5695	66	6946	86
October TOP + 1st lact.	6585	76	6745	83
October TOP + 2nd lact.	4163	48	4161	51
March TOP + 1st lact.	6591	76	6866	85
March TOP + 2nd lact.	4384	50	4306	53
1st lact. + 2nd lact.	4808	55	4284	53
October TOP + March TOP + 1st lact.	5484	63	6476	80
October TOP + March TOP + 2nd lact.	3609	42	4060	50
October TOP + 1st lact. + 2nd lact.	4802	47	4044	50
March TOP + 1st lact. + 2nd lact.	4301	50	4190	52
October TOP + March TOP + 1st lact. + 2nd lact.	3576	41	3951	49
Total number of cows in sample	8692		8097	

TABLE 2: PERCENTAGE OF FARMER ASSESSMENTS IN VARIOUS CATEGORIES IN RELATION TO SIRE BREED (1975 AND 1976 FIRST-CALVING COWS COMBINED)

Trait, Assessment and Number	*Ayrshire* Oct.	*Ayrshire* Mar.	*Friesian* Oct.	*Friesian* Mar.	*Jersey* Oct.	*Jersey* Mar.
Cups on						
Very good	65	61	62	61	61	58
Acceptable	30	35	34	36	34	37
Unsatisfactory	5	4	4	3	5	5
Number	391	381	7960	7513	6459	6304
Cups stay						
Very good	73	67	64	65	63	62
Acceptable	24	30	32	32	32	33
Unsatisfactory	3	3	4	3	5	4
Number	390	381	7930	7459	6396	6260
Mastitis						
None	95	95	92	92	92	92
Once	5	3	6	6	6	6
Several	0	2	2	2	2	2
Number	393	382	7859	7442	6414	6187
Let-down						
Very quick	60	64	52	56	57	53
Acceptable	36	33	44	41	40	44
Too slow	4	3	4	3	3	3
Number	379	381	7931	7503	6442	6272
Speed						
Very fast	43	55	45	52	52	51
Acceptable	52	42	49	44	44	46
Too slow	5	3	6	4	4	3
Number	391	379	7856	7464	6401	6268
Stripping						
Needed	6	5	8	8	7	8
Not needed	94	95	92	92	93	92
Number	374	372	7543	7112	6122	5945
Temperament						
Satisfactory	77	78	77	82	79	82
Occ. unsatis.	15	16	17	14	16	14
Often unsatis.	8	6	6	4	5	4
Number	390	380	7847	7421	6377	6213
Bloat						
None	96	94	91	91	90	91
Once	1	2	4	5	5	4
Several	3	4	5	4	5	5
Number	381	373	6937	6724	5819	5663

basis of their owners' willingness to co-operate and provide accurate records. A financial incentive is provided, along with free semen and insemination service.

Data used in this study were obtained from the herds where inseminations were made in 1972 and 1973. The resulting progeny were born in 1973 and 1974, respectively, and calved as 2-year-old heifers in the spring of 1975 and 1976. During their first lactation, production was recorded in the heifers either on a monthly or alternate monthly basis. During October and March of this first lactation a questionnaire was sent to all participating farmers. The farmers were asked to provide information concerning traits other than production (TOPs) of each animal. These results were subsequently matched up with first- and second-lactation production information. A record was kept of the herds which production recorded first-lactation animals but did not production record when these animals would have been having a second lactation. Table 1 shows the number of animals with each possible combination of data. Some difficulty was experienced in matching identification details, thus causing a lower percentage of cows having both October and March assessments than either one alone.

Table 2 shows the percentage in each category by sire breed; 1975 and 1976 first-calving cows have been combined. Differences between breeds and between October and March assessments were small. To estimate economic values, all animals having the opportunity to be production recorded for a second lactation and having complete farmer assessments for TOP in October and March were included.

Estimates of variance components were obtained using only those cows with sires identified to be young test bulls. To avoid an excessive reduction in numbers owing to missing information, each analysis was conducted for seven traits, and all cows with observations for these seven traits were included. Table 3 contains the trait combinations included in each analysis, number of sires and average number of progeny per sire. Analysis C contained the smallest number of progeny per sire owing to the absence of bloat reports for many cows. Analyses A, B and C contained traits from both March and October assessments and thus had fewer progeny per sire than D and E, which each contain traits from one assessment only.

TABLE 3: AVERAGE NUMBER OF PROGENY PER SIRE AND TRAITS INCLUDED FOR EACH ANALYSIS CONDUCTED TO ESTIMATE VARIANCE AND COVARIANCE COMPONENTS

	Analysis A	B	C	D	E
	1st fat	1st fat	1st fat	Oct. cups on	Mar. cups on
	Oct. cups on	Oct. let-down	Oct. mastitis	Oct. cups stay	Mar. cups stay
	Oct. cups stay	Oct. speed	Oct. temperament	Oct. let-down	Mar. let-down
	Oct. temperament	Oct. stripping	Oct. bloat	Oct. speed	Mar. speed
	Mar. cups on	Mar. let-down	Mar. mastitis	Oct. stripping	Mar. stripping
	Mar. cups stay	Mar. speed	Mar. temperament	Oct. temperament	Mar. temperament
	Mar. temperament	Mar. stripping	Mar. bloat	Oct. bloat	Mar. bloat
Average No. progeny/Friesian bull					
1975: 76 sires	27.4	25.1	23.1	31.0	29.3
1976: 81 sires	31.2	29.8	23.9	31.3	29.6
Average No. progeny/Jersey bull					
1975: 68 sires	24.7	23.9	21.9	30.5	28.4
1976: 67 sires	32.6	29.5	25.8	31.3	30.9

METHODOLOGY AND RESULTS

ECONOMIC VALUES

The value of a change in temperament from "satisfactory" to "occasionally unsatisfactory" is best measured by the person milking the cow. However, it is difficult for him to place this value on a monetary scale or on a scale which allows the relative values of change in different traits to be estimated.

Questionnaires aimed at measuring relative economic values tend to be either very complex to answer (*e.g.,* paper selection exercises) or simple to answer but do not provide estimates of economic values (*e.g.,* Which trait do you consider most important, temperament or ease of milking?).

At the end of each season a certain percentage of the cows in each herd are culled. In making the culling decisions a farmer must weigh up all the information he has about each cow.

He has to combine what he knows about a cow's production, fertility, temperament, ease of milking, tendency to bloat and appearance, in a way that enables him to decide whether to keep or cull. In combining this information he must assign, subconsciously at least, relative economic values to each trait.

By comparing the survival rate of cows according to their TOP scores it is possible to estimate the economic value assigned to each by farmers.

A linear model was fitted to survivals, expressed as 0 for culled and 1 for not culled, and the factors included were the TOP assessments from October and March. Also included in the model were linear and quadratic terms for milk-fat yield.

Estimates were obtained using least squares procedures. The first level of each factor was restricted to zero to ensure a full rank set of equations. The estimates obtained are given in Table 4. Two sets of estimates were obtained, one for each of the 2 years' data. Standard errors of the estimates were approximately the same in each year and for October and March. They are contained in the last column of Table 4. A negative estimate indicates that survival is being lowered by the particular variation of a trait relative to the first level. For example, the estimate from the 1975 data for a cow which had mastitis several times by October is −0.169, indicating that, relative to a cow with no mastitis, survival is reduced by 16.9%, all other things being equal.

Several of the estimates which are positive were expected to be negative. For example, unsatisfactory cups staying on in both

1975 and 1976 have positive estimates. The relatively large standard errors may explain this. However, it is also likely that, if all other things are equal, whether or not cups stay on well makes little difference to the chances that a cow will be culled.

The effects of undesirable levels of TOP shown in Table 4 indicate that the most significant factors influencing survival are

TABLE 4: ESTIMATES OF EFFECTS FROM A LINEAR MODEL FITTED TO SURVIVAL FROM FIRST TO SECOND LACTATION

	1975 1st Calving[1]		*1976 1st Calving*[1]		
	Oct.	*Mar.*	*Oct.*	*Mar.*	*SE*
Cups on					
Very good	0.0	0.0	0.0	0.0	
Acceptable	0.016	–0.044	–0.040	0.008	0.02
Unsatisfactory	–0.035	–0.126	–0.016	0.042	0.04
Cups stay					
Very good	0.0	0.0	0.0	0.0	
Acceptable	0.006	0.022	0.002	–0.017	0.02
Unsatisfactory	0.020	0.015	0.021	–0.076	0.05
Mastitis					
None	0.0	0.0	0.0	0.0	
Once	–0.004	–0.055	–0.042	–0.065	0.03
Several	–0.169	–0.121	–0.026	–0.185	0.06
Let-down					
Very quick	0.0	0.0	0.0	0.0	
Acceptable	–0.025	0.010	0.001	–0.021	0.02
Too slow	–0.015	–0.079	–0.071	–0.102	0.05
Speed					
Very fast	0.0	0.0	0.0	0.0	
Acceptable	0.026	0.023	0.027	0.005	0.02
Too slow	–0.034	–0.010	0.027	–0.107	0.05
Stripping					
Needed	0.0	0.0	0.0	0.0	
Not needed	0.037	0.015	–0.005	–0.017	0.03
Temperament					
Satisfactory	0.0	0.0	0.0	0.0	
Occ. unsatis.	0.009	–0.040	–0.009	–0.010	0.02
Often unsatis.	–0.083	–0.124	–0.020	–0.218	0.04
Bloat					
None	0.0	0.0	0.0	0.0	
Once	0.0127	0.0477	0.011	–0.116	0.04
Several	0.0493	–0.0146	0.050	–0.008	0.04
Fat yield — 160	0.00208/kg		0.00262/kg		0.00017
(Fat yield — 160)^2	–0.0000189/kg^2		–0.0000225/kg^2		
Constant	0.79		0.87		
R^2	0.11		0.12		

[1]A separate analysis was conducted for each of the 2 years of first calving. All factors included in the model are contained in this table.

fat yield, mastitis and temperament. Unfortunately, pregnancy information was not available for inclusion in the model. This would possibly help account for much of the unexplained variation. A further refinement to the model would be to include herd as a factor. Herds vary in the level of culling, the standards used for assessing traits, and the measures taken to prevent bloat, bad temperament, mastitis and machine stripping. Preliminary work using herd as part of the model indicates that survival becomes more accurately predicted, and factors such as increasing bloat are estimated to have a much more negative influence on survival. Clearly the model needs more research.

To convert survival estimates to relative economic values, the effect that each trait has on survival was related to the effect that fat yield has on survival. Only the linear component of fat yield was used. At a yield of 160 kg fat, a 10 kg decrease in yield results in approximately a 2% decrease in survival. Thus if an occasionally unsatisfatory March temperament causes a 4% reduction in survival, it has the same economic value as a 20 kg decrease in yield. Economic values obtained in this manner are contained in Table 5.

Expressing economic values in terms of kg fat equivalent is convenient in that it gives values which are more easily understood than those based on relative survival rates.

Table 5 shows very clearly the high negative economic value associated with frequent mastitis and poor temperament. It also shows that March assessments are more significant in culling decisions than October assessments. This seems reasonable since March is nearer to the usual time of culling. However, a separate analysis showed that cows culled between October and March had a higher frequency of the undesirable characteristics in October than the cows contributing to this analysis. This would cause the influence of the October assessment on survival, as estimated using assessments on cows also present in March, to be biased. The March estimates of economic values are thus more likely to be unbiased.

The estimated relative economic values contained in Table 5 refer to a completely categorized scale for each trait. At no point in the estimation procedure is it necessary to make an assumption about the distance between the categories. In evaluating a breeding programme it is necessary to be able to place the categories on some form of scale. There are a large number of possible methods of doing this, and the final choice is always to some extent arbitrary.

TABLE 5: ECONOMIC VALUES IN kg FAT (AVERAGE OF 1975 AND 1976 ESTIMATES)

	Oct.	*Mar.*
Cups on		
Very good	0.0	0.0
Acceptable	–5.1	–7.7
Unsatisfactory	–10.8	–17.9
Cups stay		
Very good	0.0	0.0
Acceptable	1.7	1.0
Unsatisfactory	8.7	–12.9
Mastitis		
None	0.0	0.0
Once	–8.1	–25.5
Several	–41.5	–65.1
Let-down		
Very quick	0.0	0.0
Acceptable	–5.1	–2.3
Too slow	–18.3	–38.5
Speed		
Very fast	0.0	0.0
Acceptable	11.3	6.0
Too slow	–1.5	–25.9
Stripping		
Needed	0.0	0.0
Not needed	6.8	–0.4
Temperament		
Satisfactory	0.0	0.0
Occ. unsatis.	0.0	–10.6
Often unsatis.	–21.9	–72.8
Bloat		
None	0.0	0.0
Once	5.0	–14.5
Several	21.7	–4.8

Assessments were converted to a 1, 2, 3 scale in the order shown in Table 5. For example, very good cups on was scored 1, acceptable 2, and unsatisfactory 3. The economic value of a change in mean score caused, for example, by selecting appropriate sires was estimated by assuming an underlying normally distributed variable for each trait. This is illustrated in Fig. 1. For any population divided into three categories with a known percentage in each category it is always possible to find t_1 and t_2. In this model we assume t_1 and t_2 remain fixed and a change in progeny mean score results when a better or worse bull is used.

If a bull is capable of increasing the mean score, then the economic value of this increase is determined by the change in the percentage of progeny in each category and the relative

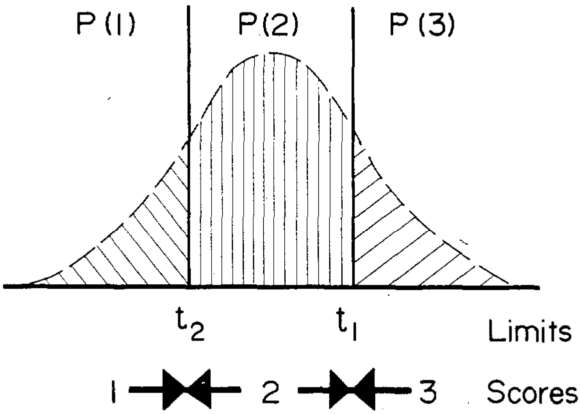

FIG. 1: *Model assumed for underlying variable controlling farmer's assessment of each trait.*

In the population a percentage [P (1)] of the cows are assessed to be in category 1 and are given a score of 1. All of these cows have a value for the underlying variable which is less than t_2. Cows in category 2 are between t_2 and t_1 and are scored 2. Cows in category 3 are above t_1 and are scored 3.

economic value of each category. It is possible, using normal distribution theory, to calculate the amount by which the expected progeny economic value changes for a unit change in mean score. The resulting estimates are contained in Table 6. Because of the non-linear nature of the relationship between mean score and economic value, the slope differs according to the mean score. For example, October let-down has an economic value of –6.3 kg fat/unit change in score at a mean score of 1.45, but at a mean score of 1.51 the economic value is –6.5 kg/unit change in score. In other words, a change in October let-down is of more economic significance (up or down) when the mean score indicates slow let-down.

Genetic and Phenotypic Parameters

Estimates of sire and error variances and covariances were obtained for the scores using a simple linear model including sire and error as random factors. Ideally, herds should have been included in the model as a fixed factor, but computer limitations

TABLE 6: ECONOMIC VALUES (kg FAT) IN THE REGION OF THE MEAN SCORE FOR EACH TRAIT

Trait	*Score*	*Oct.*	*Mar.*
Cups on	–0.05	–5.2	–8.1
	mean	–5.1	–8.3[1]
	+0.05	–5.2	–8.3
Cups stay	–0.06	2.7	–1.4
	mean	2.9	–1.7
	+0.04	2.9	–2.0
Mastitis	–0.02	–14.3	–28.6
	mean	–14.2	–28.9
	+0.02	–14.8	–29.9
Let-down	–0.04	–6.1	–6.5
	mean	–6.3	–7.3
	+0.06	–6.5	–8.1
Speed	–0.05	7.5	1.30
	mean	7.0	0.43
	+0.05	6.4	–0.40
Stripping	–0.01	6.5	–0.6
	mean	6.8	–0.7
			–0.8
Temperament	–0.03	–5.4	–20.1
	mean	–5.9	–21.0
	+0.05	–6.3	–22.1
Bloat	–0.03	9.1	–5.2
	mean	9.3	–5.2
	+0.03	9.3	–4.9

[1] Underlined economic values were used in selection indexes constructed.

prevented this. However, the design of the progeny tests is such that each sire is represented in a herd by (on average) one or two daughters. For herd variance to inflate the sire variance there would need to be a non-random confounding or herd with sire. Because of the large number of traits (17) and limited computer resources, not all covariances were estimated.

Table 7 shows the estimated heritabilities for each trait. Each value is the average of the estimates from 1975 and 1976. The estimates are slightly higher than those obtained previously. Genetic correlation estimates have been averaged and are summarized in Table 8.

TABLE 7: HERITABILITY ESTIMATES[1] OBTAINED FROM SCORED DATA BY PATERNAL HALF SIB ANALYSIS

	Friesian		*Jersey*	
Trait Scored	*Oct.*	*Mar.*	*Oct.*	*Mar.*
Cups on	0.06	0.07	0.08	0.06
Cups stay	0.05	0.06	0.08	0.04
Mastitis	0.05	0.09	0.02	0.01
Let-down	0.08	0.07	0.05	0.06
Speed	0.08	0.15	0.09	0.13
Stripping	0.06	0.07	0.11	0.06
Temperament	0.11	0.12	0.11	0.09
Bloat	0.08	0.08	0.13	0.03

[1] Average of estimates from 1975 and 1976 data.

The estimates show high positive correlations between the same traits in different assessments (October and March), a high positive correlation between cups on and cups staying on, and between speed of let-down and milking speed. Cups staying on are positively correlated with speed of let-down, and to a lesser extent with milking speed. Stripping shows a negative correlation with speed of let-down and milking speed. This indicates that more stripping is needed for cows with slow let-down and slow milking speed. Relationships between the non-production traits and fat yield vary greatly. None of the estimates exceed their standard errors. Likewise, the genetic correlation between bloat and all other traits was not significantly different from zero.

Inclusion of Non-production Traits in Selection Indices

Estimates of variance and covariance components for each breed in each year were used to evaluate five alternative methods of bull selection. Each method assumed the bulls would be progeny tested on 40 daughters for each trait recorded. The five alternatives have varying amounts of production and non-production recording of the daughters. For each alternative a selection index was constructed using the economic values underlined in Table 6 for both October and March and the variance/covariance components obtained for each breed-by-year combination.

Table 9 contains a summary of the resulting projections of economic gains. The table shows gain relative to alternative 1 where production, October TOPs and March TOPs are all used in bull selection. Alternatives 2 and 3 have the October and March assessments deleted, while 4 uses fat yield only and 5 uses October and March assessments without any fat yield recording.

TABLE 8: ESTIMATED GENETIC CORRELATIONS[a] BETWEEN SCORED TRAITS IN OCTOBER AND MARCH (DIAGONAL), BETWEEN DIFFERENT TRAITS IN SAME MONTH (ABOVE DIAGONAL), AND BETWEEN DIFFERENT TRAITS IN DIFFERENT MONTHS (BELOW DIAGONAL)

		(2)	(3)	(4')	(5)	(6)	(7)	(8)	(9)
Fat yield	(1)	–0.06 ± 0.11	0.03 ± 0.16	0.01 ± 0.20	–0.02 ± 0.29	0.16 ± 0.18	–0.05 ± 0.13	–0.15 ± 0.15	0.10 ± 0.12
Cups on	(2)	0.84 ± 0.06	0.87 ± 0.06	—	0.66 ± 0.11	0.37 ± 0.14	–0.10 ± 0.21	0.39 ± 0.09	–0.23 ± 0.29
Cups stay	(3)	0.83 ± 0.11	0.81 ± 0.09	—	0.66 ± 0.16	0.43 ± 0.16	–0.02 ± 0.26	0.35 ± 0.15	–0.11 ± 0.30
Mastitis	(4)	—	—	0.45 ± 0.26	— *b*	—	—	0.01 ± 0.24	0.18 ± 0.25
Let-down	(5')	—	—	—	0.93 ± 0.02	0.94 ± 0.04	–0.47 ± 0.16	0.30 ± 0.16	0.01 ± 0.20
Speed	(6)	—	—	—	0.82 ± 0.10	0.78 ± 0.19	–0.67 ± 0.11	0.22 ± 0.12	–0.03 ± 0.21
Stripping	(7)	—	—	—	–0.40 ± 0.07	–0.54 ± 0.16	0.92 ± 0.05	–0.26 ± 0.16	–0.20 ± 0.20
Temperament	(8)	0.38 ± 0.13	0.33 ± 0.02	0.21 ± 0.16	—	—	—	0.82 ± 0.12	–0.04 ± 0.18
Bloat	(9)	—	—	0.11 ± 0.17	—	—	—	–0.02 ± 0.26	0.73 ± 0.09

[a] Genetic correlations are average of estimates obtained from Jersey and Friesian 1975 and 1976 data. For fat yield, average is also taken across October and March estimates. *b* — indicates — Not estimated.

TABLE 9: RELATIVE GENETIC GAINS AND CONTRIBUTIONS (%) TO GAIN MADE BY EACH TRAIT FOR FIVE ALTERNATIVE METHODS OF SELECTION

Variables Used in Selection Index	*Relative Economic Gain*	*Fat Yield*	*Cups On*	*Cups Stay*	*Mastitis*	*Let-down*	*Speed*	*Stripping*	*Temperament*	*Bloat*
(1) Fat, all Oct. TOPs, all Mar. TOPs	100	83	1.9	0.2	1.8	0.2	0.0	0.0	13.7	–0.7
(2) Fat, all Oct. TOPs	98	84	1.9	0.2	1.5	0.4	0.0	0.0	13.0	–0.8
(3) Fat, all Mar. TOPs	97	86	1.5	0.1	1.6	–0.1	0.1	0.0	11.8	–0.8
(4') Fat	91	96	0.1	–0.1	0.2	–0.3	0.1	0.0	4.9	–0.8
(5) All Oct. TOPs, all Mar. TOPs	80	75	2.9	0.3	2.6	–0.2	0.1	0.0	20.0	–0.7

The main body of the table shows the percentage contribution each trait would be expected to make to total economic gain. These percentages are averages over the four estimates obtained by using the genetic and phenotypic parameters from each of the two breeds and two years.

DISCUSSION

A large-scale breeding scheme for dairy cattle, as operated by the Dairy Board, should include all economically important characteristics in its objective. The results of this study indicate that the non-production traits, cups on, mastitis, speed of let-down, temperament and bloat, are economically important and should be included in the breeding objective.

Another trait which should be given serious consideration is female fertility. It would be a relatively simple exercise to collect pregnancy data on bulls' daughters. Once available, these data could be used to evaluate the economic importance of fertility as well as the role that genetics plays in its determination.

Once economic values and genetic/phenotypic parameters are established, it is then necessary to decide which traits should be measured and used in making bull selection decisions. All of the non-production traits are characterized by low heritabilities, indicating that large progeny groups are needed for accurate sire evaluation. Simulations using a simple selection index and assuming progeny groups of 40 animals indicate that 83% of improvement in economic terms will be in the form of milk fat; 14% is in the form of an improvement in temperament. With larger progeny groups it would seem likely that the total gain would increase and the percentage contribution of the non-production traits would also increase. Investigation of the possibility of increasing the size of progeny groups is clearly warranted.

The method used in this study to quantify variation in the non-production traits is quite arbitrary and may not be a good indication of the true biology involved. For this reason it seems likely that further research into the biology of the economically important traits could reveal much better methods for quantifying the differences between cows and the genetic differences between sires.

The approach used in this paper to estimate economic values may best be described as a first approximation which, despite its limitations, shows that it can be used to contribute to progress in the breeding of better dairy cattle for New Zealand.

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