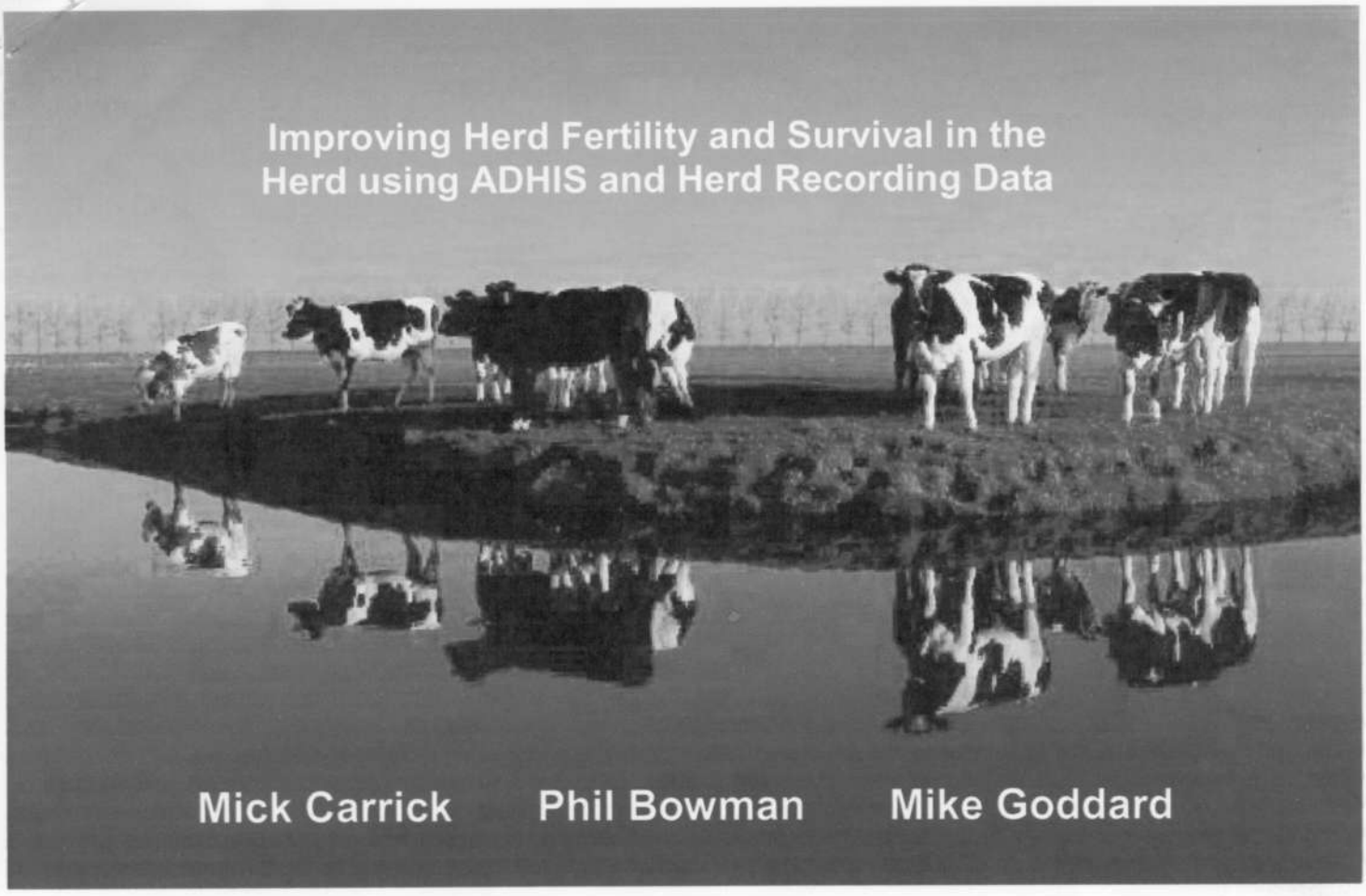
Improving Herd Fertility and Survival in the Herd using ADHIS and Herd Recording Data



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Primary Industries Research Victoria

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Appendix 5: Article 3 for the Dairy Farmer

Crossbreeding Dairy Cattle

Part 3: Economic Evaluation of Cross Breeding Options

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Introduction

The first two parts of this series covered the performance of six breeds of cows and their crosses and back crosses to either Holstein or the other parent breed as well as outcrosses to other breeds. In this part we cover economic evaluation of the traits for which we have breed and cross breed data and analyses.

The economic values

Fortunately, ADHIS has conducted a careful analysis to produce economic values. These are used, with the relevant ABVs to form a selection index called the Australian Profit Ranking (APR). Because we are dealing with breed and cross breed effects, we can use the APR values in a similar way to compare the increase (or decrease) in profit as a result of a shift from Holstein to a range of other options.

The values used in the APR are:

Milk volume	-$0.038
Fat kg	$1.06
Protein kg	$3.59
Inter-calving Interval	-$0.66
Survival	$4.56

Note that these values represent the change in profit from a one-unit change in the trait. They are not the same as the index weights used to select for these traits.

The dollar value for inter-calving interval is based on the regression of six-week pregnancy rate on inter-calving interval from a DRDC project by Dr Mekonnen Haile-Mariam. As in previous articles, we lack data on body weight, feed conversion efficiency and heat production and knowledge of these may modify the economics to some extent. A further caveat is that some of the survival results may be affected by voluntary decisions by the farmer rather than the result of mastitis, lameness or death of the cow herself. Since survival has a high economic value, possible inaccuracies of this type are magnified. So these sets of estimates should be used only as a rough guide to changes in profit as a result of choosing crossbreeding options.

All options are compared with straight Holstein cows so that values above zero are more profitable than Holstein and less than zero are less so. As in the last article, the levels of heterosis assumed in all crosses are estimates from the Holstein x Jersey crosses and backcrosses because we had much more data for these crosses than for the others.

Table 1 Economic values of average differences from straight Holstein in six straight breeds.

Average Values* of straight breeds	Jersey	Ayrshire	Illawarra	Guernsey	Aust Red	Brown Swiss
Milk (kg)	$57.42	$25.08	$25.16	$40.32	$17.71	$21.81
Fat (kg)	-$25.07	-$22.75	-$30.79	-$24.33	-$9.84	-$13.23
Protein (kg)	-$109.50	-$58.16	-$59.95	-$85.44	-$28.00	-$28.72
Inter-calving interval (days)	$2.95	$2.89	$1.51	$0.59	$2.63	$2.63
Survival %	-$33.29	-$19.15	-$49.70	-$51.07	$3.19	$32.83
Totals	**-$107.49**	**-$72.09**	**-$113.78**	**-$119.94**	**-$14.32**	**$15.33**

* Relative to straight Holstein

It needs to be emphasized that we have no data on body weight and that is a clear deficiency because the Holstein is the largest of these breeds and the Jersey the smallest. There are most likely substantial feed intake and possibly conversion efficiency differences related to these differences in size. However, it appears that the trend for Jersey, Ayrshire, Illawarra and Guernsey breeders to move to Holstein is based, at least in part, on relative income. Summed over the average 175-cow dairy, this advantage of the Holstein over the four breeds, ranges from approximately $12,600 to almost $21,000 for these four breeds. In the case of Australian Red and Brown Swiss the difference from Holstein is much smaller with the Australian Red slightly less (-$2,500) and the Brown Swiss ($2,700) slightly more profitable than Holstein. Some of the cross breeding options can make up some of this ground and may be attractive alternatives. In the following table are similar values for F1 crosses of the six breeds compared to Holstein.

Table 2 Economic values of F1 crosses between Holstein and the six other breeds, expressed as deviations from straight Holstein.

F1 Cross of Holstein x	Jersey	Ayrshire	Illawarra	Guernsey	Aust Red	Brown Swiss
Milk (kg)	$19.02	$2.85	$2.89	$10.47	-$0.84	$1.22
Fat (kg)	$1.64	$2.80	-$1.22	$2.01	$9.26	$7.56
Protein (kg)	-$20.64	$5.03	$4.13	-$8.62	$20.10	$19.75
Inter-calving interval (days)	$2.46	$2.43	$1.74	$1.28	$2.30	$2.30
Survival %	$2.51	$9.58	-$5.70	-$6.38	$20.75	$35.57
Totals	**$4.99**	**$22.68**	**$1.84**	**-$1.24**	**$51.57**	**$66.39**
Totals excluding survival	**$2.48**	**$13.11**	**$7.54**	**$5.14**	**$30.82**	**$30.82**

Whereas most of the alternative straight breeds reduced profit relative to Holstein, the F1 crosses mostly increased it. This was because the value of heterosis, fully expressed in the F1, made up for the loss from the additive breed values. Even if we exclude the advantage of increased survival (which has a high value but might be influenced by farmer policy decisions), the result is generally positive. Of the F1s present in the data set, the most promising were the Australian Red (+$9.000) and Brown Swiss by Holstein (+$11,600). In all cases, the choice of the sire within the chosen breed adds its effect to the averages shown. For example, in most breeds, the top 1% of bulls at AI are in the order of $100 above the average bull and would further boost the 175-cow dairy by approximately $17,500.

Having arrived at an F1 population, the interesting question is: What do we do next? The options include backcrossing to one or the other parental breed, crossing the F1 with a third breed, which can then be rotated through another cycle of crossing. There are many possibilities to examine, but we will be looking first at the backcrosses to one or another parent breed. Unfortunately, in dairy cow breeding, it is very rare to have a crossbred bull available as an option so the possibility of a composite or synthetic breed, as often employed in the beef industry, is more difficult.

The two types of genetic effects in crossbreeding need to be considered separately. First, the additive breed value of a cross is simply the proportional influence of each breed's additive value. For example, if we start at the F1 cross, the additive breed values are simply averaged to give us a mid-parent mean. When we backcross, the amount of one breed becomes ¾ and of the other ¼.

Heterosis behaves a little differently. In the F1 we have all of the heterosis expressed and we can predict the progeny value by adding the levels of heterosis to the mid-parent mean. In general, heterosis is proportional to the degree of unrelatedness with the maximum being a hybrid between two breeds (the opposite of inbreeding). Many combinations are possible with the expression of heterosis ranging from 100% in the F1 down to zero in the straight breed. In the backcross, the unrelatedness of parents is only half what it was in the F1 so we add half the level of heterosis to the proportional breed additive value.

The best way to use all this is to make decisions based on the predicted progeny performance for each possible option. This can become complex as we proceed into a crossing program, but we can get a feel for the possibilities by looking at the backcrosses and some alternatives beyond that.

Table 3 Predicted values of the backcross to Holstein from the respective F1 crosses.

F1 Cow Breed:	Jersey x Holstein	Ayrshire x Holstein	Illawarra x Holstein	Guernsey x Holstein	Aust Red x Holstein	Brown Swiss x Holstein
Average Values* for back-cross of F1s to:	Holstein	Holstein	Holstein	Holstein	Holstein	Holstein
Milk (kg)	$9.51	$1.43	$1.44	$5.23	-$0.42	$0.61
Fat (kg)	$0.82	$1.40	-$0.61	$1.01	$4.63	$3.78
Protein (kg)	-$10.32	$2.51	$2.06	-$4.31	$10.05	$9.87
Inter-calving interval (days)	$1.23	$1.21	$0.87	$0.64	$1.15	$1.15
Survival %	$1.25	$4.79	-$2.85	-$3.19	$10.37	$17.78
Totals	$2.49	$11.34	$0.92	-$0.62	$25.79	$33.20

* Relative to straight Holstein

Only the ¼ Guernsey ¾ Holstein was marginally lower in average profit value than Holstein. The others were slightly positive and the ¼ Australian Red ¾ Holstein and ¼ Brown Swiss ¾ Holstein appear to remain promising options.

The other back crosses are more different since they are all ¼ Holstein and ¾ each of the other breeds.

Table 4 Predicted values of the back cross of F1 Holstein cows with the non-Holstein breed

F1 Cow Breed:	Jersey x Holstein	Ayrshire x Holstein	Illawarra x Holstein	Guernsey x Holstein	Aust Red x Holstein	Brown Swiss x Holstein
Average Values* for back-cross of F1s to:	Jersey	Ayrshire	Illawarra	Guernsey	Aust Red	Brown Swiss
Milk (kg)	$38.22	$13.97	$14.02	$25.39	$8.44	$11.51
Fat (kg)	-$11.72	-$9.97	-$16.00	-$11.16	-$0.29	-$2.83
Protein (kg)	-$65.07	-$26.57	-$27.91	-$47.03	-$3.95	-$4.49
Inter-calving interval	$2.71	$2.66	$1.62	$0.94	$2.46	$2.46
Survival %	-$15.39	-$4.79	-$27.70	-$28.73	$11.97	$34.20
Totals	-$51.25	-$24.70	-$55.97	-$60.59	$18.63	$40.86

* Relative to straight Holstein

In this table, the non-Holstein breeds dominate the additive value and most compare unfavourably with the alternative back cross to Holstein. Once again, the Australian Red back cross is positive and not very different from the alternative back cross in value and the Brown Swiss back cross is even more profitable than the Holstein back cross.

If we have F1 crosses from high ASI sires in the herd, and are considering what to do next, then the back cross to Holstein is reasonably safe although not very different to keeping straight Holsteins. If the F1s are Australian Red or Brown Swiss by Holstein then either back cross will be a profitable option.

Finally, to whet our appetites for what else might be achieved, we will evaluate a set of options when breeding on from the F1. Each of the remaining tables shows the breed composition and heterosis expressed and the profit effects of each.

Table 5 Breed composition, heterosis and values of F1 crosses of Holstein with Jersey, Australian Red or Brown Swiss cows, relative to straight Holstein.

F1 Crosses	Breed Proportions							
	Holstein	Jersey	Aust Red	Brown Swiss	Additive Breed value	Heterosis expression	Heterosis Value	Average Value *
Jersey-Holstein	0.5	0.5	0	0	-$53.74	1	$58.73	$4.99
Aust Red-Holstein	0.5	0	0.5	0	-$7.16	1	$58.73	$51.57
Brown Swiss-Holstein	0.5	0	0	0.5	$7.66	1	$58.73	$66.39

Various combinations of the other breeds may well also produce positive results for particular crosses, but these were chosen because of the many useful options among them.

The range of profit values of the many options relative to straight Holstein is of the same order as between the most and least profitable bulls available through AI. These ABV values as presented in the Australian Profit Ranking are additive (that half of the sire's

APR advantage is inherited by the progeny). For example the six back-cross options (Table 6) range in profit relative to straight Holstein from -$51.25 to +$40.86. Among the outcrosses from the backcross cows (Table 7), the range of profit relative to Holstein is -$23.13 to +$64.60, with a third of the options over $50.00 more than straight Holstein.

In summary, given the correct choices of breeds and crosses, crossbreeding appears to be profitable over at least three generations relative to straight Holstein. The advantage of around $11,600 per lactation over an average 175-cow herd.

The profit advantages mentioned above are independent of the choice of bulls through APR values and therefore the latter remain an important source of information towards maximising dairy profit.

Table 6 Breed compositions, heterosis expressed and profit value in the backcrosses generated from matings of the three F1s listed above

	Backcrosses	Holstein	Jersey	Aust Red	Brown Swiss	Additive Breed value	Heterosis expression	Heterosis Value	Average Value *
		Breed Proportions							
BC1	Jersey x Jersey-Holstein	0.25	0.75	0.00	0.00	-$80.61	0.50	$29.36	-$51.25
BC2	Holstein x Jersey-Holstein	0.75	0.25	0.00	0.00	-$26.87	0.50	$29.36	$2.49
BC3	Aust Red x Aust Red-Holstein	0.25	0.00	0.75	0.00	-$10.74	0.50	$29.36	$18.63
BC4	Holstein x Aust Red-Holstein	0.75	0.00	0.25	0.00	-$3.58	0.50	$29.36	$25.79
BC5	Brown Swiss x Brown Swiss-Holstein	0.25	0.00	0.00	0.75	$11.49	0.50	$29.36	$40.86
BC6	Holstein x Brown Swiss-Holstein	0.75	0.00	0.00	0.25	$3.83	0.50	$29.36	$33.20

* Relative to straight Holstein

In the following table we show the possible out-crosses from matings of the breed compositions above with sires from the most unrelated breeds among the four. These have been called out-crosses and many more are possible than have been shown here. Some of these out-crosses offer the possibility of retaining most of the heterosis for little trade-off in additive breed value. One third of the outcross options shown in Table 7 increase profit by $50 or more. To this can be added the gain from selecting sires with high APR values.

Table 7 Summaries of the breed compositions, heterosis expressed and the dollar values relative to straight Holstein of possible matings of the backcrosses with Holstein, Jersey, Australian Red or Brown Swiss bulls. BC1 to BC6 refer to the backcrosses listed in Table 6.

						Additive Breed value	Heterosis expression	Heterosis Value	Average value *
		Holstein	Jersey	Aust Red	Brown Swiss				
	Outcrosses	Breed Proportions							
OC1	Holstein x BC1	0.625	0.375	0.000	0.000	-$40.31	0.75	$44.05	$3.74
OC2	Aust Red x BC1	0.125	0.375	0.500	0.000	-$47.46	1.00	$58.73	$11.26
OC3	Brown Swiss x BC1	0.125	0.375	0.000	0.500	-$32.64	1.00	$58.73	$26.08
OC4	Jersey x BC2	0.375	0.625	0.000	0.000	-$67.18	0.75	$44.05	-$23.13
OC5	Aust Red x BC2	0.375	0.125	0.500	0.000	-$20.59	1.00	$58.73	$38.14
OC6	Brown Swiss x BC2	0.375	0.125	0.000	0.500	-$5.77	1.00	$58.73	$52.96
OC7	Jersey x BC3	0.125	0.375	0.500	0.000	-$47.46	1.00	$58.73	$11.26
OC8	Holstein x BC3	0.625	0.000	0.375	0.000	-$5.37	0.75	$44.05	$38.68
OC9	Brown Swiss x BC3	0.125	0.000	0.375	0.500	$2.29	1.00	$58.73	$61.02
OC10	Jersey x BC4	0.375	0.500	0.125	0.000	-$55.53	1.00	$58.73	$3.20
OC11	Brown Swiss x BC4	0.375	0.000	0.125	0.500	$5.87	1.00	$58.73	$64.60
OC12	Aust Red x BC4	0.375	0.000	0.625	0.000	-$8.95	0.75	$44.05	$35.10
OC13	Holstein x BC5	0.625	0.000	0.000	0.375	$5.75	0.75	$44.05	$49.79
OC14	Aust Red x BC5	0.125	0.000	0.500	0.375	-$1.41	1.00	$58.73	$57.32
OC15	Jersey x BC5	0.125	0.500	0.000	0.375	-$48.00	1.00	$58.73	$10.73
OC16	Jersey x BC6	0.375	0.500	0.000	0.125	-$51.83	1.00	$58.73	$6.90
OC17	Aust Red x BC6	0.375	0.000	0.500	0.125	-$5.24	1.00	$58.73	$53.49
OC18	Holstein x BC6	0.875	0.000	0.000	0.125	$1.92	0.25	$14.68	$16.60

* Relative to straight Holstein

One of the concerns in this study is the possibility that the survival values are a reflection of farmers' breeding or crossbreeding policies rather than a biological trait of the cow. If we do the calculations of Tables 6 and 7 to exclude the effects of survival on profit changes, the range of values of different options changes, usually downward. For example, in the six backcross options from Table 6, the range of values is reduced to -$36.76 to +$14.52 and the same range in the outcrosses (Table 10) becomes -$18.03 to +$26.84 when survival is excluded. The true values of survival as a biological property of the cow will lie somewhere between these extremes and those in the previous paragraph..

In summary, crossbreeding can be more profitable over at least three generations relative to straight Holstein and the advantage of up to $9,000 per lactation over an average 175-cow herd, while not huge, could none-the-less be a very useful change.

It is not necessary to embark on a fixed crossbreeding plan, but it is possible get close to the optimum by choosing mates for our cows based on breed values, individual ABVs and