Daughter fertility breeding values in Australian dairy herds

John Morton

10 July 2020

Aims

The aims of this work were to describe daughter fertility breeding values in cows in a subset of Australian dairy herds, and to describe effects of two rates of increase in sire daughter fertility breeding values on 6-week in-calf rates under some simplifying assumptions. This report focusses on Holstein-Friesian cows (cows with breed code 'FFFF').

This work is part of a larger project assessing changes in reproductve performance over time and causes of such changes.

Data

All data used in this work were extracted from DataGene's database. Mating periods (or, for year-round calving herds, 12-month calving periods) with high quality reproductive data (essentially periods where early rectal pregnancy tests were available for a high proportion of lactations) were identified and all relevant data extracted. Daughter fertility breeding values as calculated in April 2020 were used. Numbers of lactations by year are shown in Table1.

Table 1. Numbers of lactations included in analyses for cows of all breeds by year of calving date

Year	Seasonal	Split	Year-round	Pooled
2000	4,883	1,404	0	6,287
2001	7,530	1,521	0	9,051
2002	12,611	4,931	344	17,886
2003	10,149	5,160	524	15,833
2004	10,904	6,909	2,009	19,822
2005	16,340	12,187	1,909	30,436
2006	22,944	14,683	826	38,453
2007	23,835	12,072	4,400	40,307
2008	28,648	15,277	4,567	48,492
2009	21,991	15,461	3,160	40,612
2010	17,887	16,024	4,992	38,903
2011	21,026	19,868	3,115	44,009
2012	18,078	19,839	6,511	44,428
2013	32,453	38,307	19,704	90,464
2014	38,737	43,990	26,407	109,134
2015	37,001	41,476	24,975	103,452
2016	29,733	37,453	22,063	89,249
2017	27,992	35,157	17,446	80,595
2018	9,127	17,659	9,344	36,130
Pooled	391,869	359,378	152,296	903,543

Daughter fertility breeding values by year

Sire daughter fertility breeding values for Holstein-Friesian cows by year of birth are shown in Figure 1 for cows born from 2000 to 2016. Only cows with atleast one calving immediately prior to a mating period with high quality reproductive data were used.

Sire daughter fertility breeding values varied widely within all years of birth. Median values declined until year of birth 2001, plateaued to 2011 before increasing to year of birth 2016.
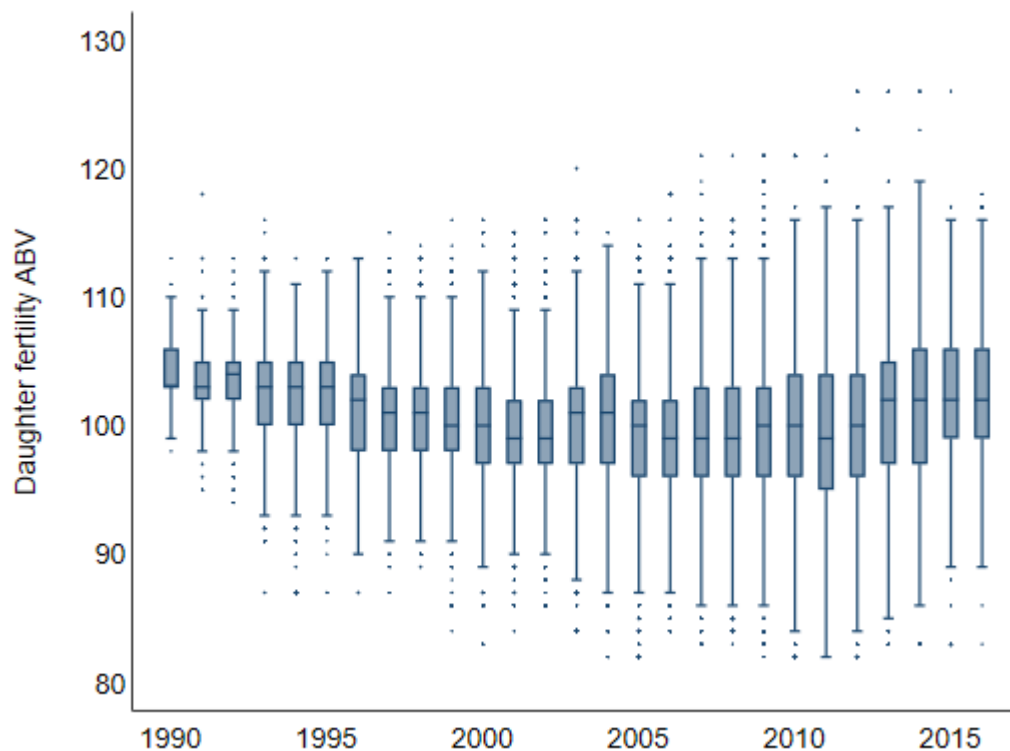
Figure 1. Distribution of Holstein-Friesian cows by their sire's daughter fertility breeding value, by cow's year of birth for cows with atleast one calving immediately prior to a mating period with high quality reproductive data. Boxes contain the middle 50% of cows (ie the 25th percentile up to the 75th percentile of cows; horizontal line within box indicates median; error bars extend to 1.5 times box height above the 75th percentile and 1.5 times box height below the 25th percentile; markers indicate cows with more extreme sire daughter fertility breeding values

This same pattern is evident in mean sire daughter fertility breeding values for Holstein-Friesian cows by cow's year of birth (Figure 2; lower (blue) line).
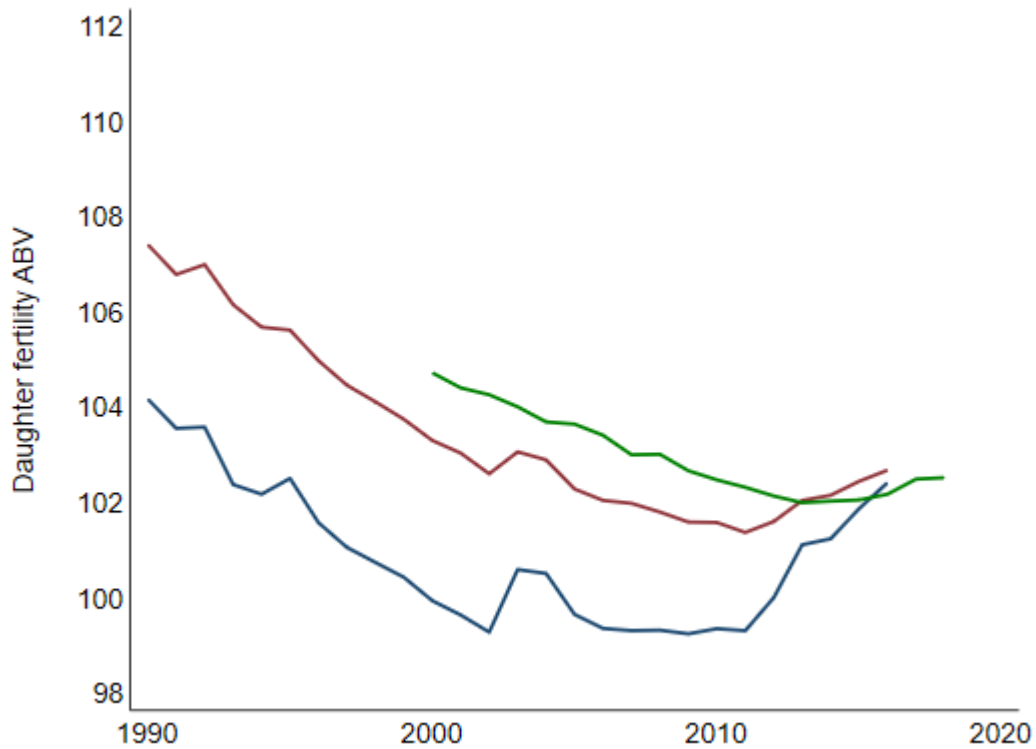
Means of <u>cow</u> daughter fertility breeding values for the same cows are also shown by cow's year of birth (Figure 2; lower (maroon) line). These are higher than the sire daughter fertility breeding values for the same cows because the daughter fertility breeding values for the cow's sires were, on average, lower than those for the cows' dams. Once sire daughter fertility breeding values increased, the gap narrowed as the daughter fertility breeding values for the cow's sires moved closer to those for the cows' dams. With further increases in sire daughter fertility breeding values, these will exceed those for the cows' dams and hence for the cows. Over a long period of constant rate of increase in sire daughter fertility breeding values, the blue and red lines would be expected to become parallel but with the mean sire daughter fertility breeding values (blue line) above mean cow daughter fertility breeding values for the same cows (maroon line), as the sires 'pull' the cows up.

Means of <u>cow</u> daughter fertility breeding values for all cows that <u>calved</u> by year of calving are of major importance as these describe the genetic status for fertility of the herd, that is, of all cows that the famer is aiming to get pregnant in that year. Thus, if herd fertility is to be increased in a particular year due to improved genetics, the cow daughter fertility breeding values for cows that calved in that year must be increased relative to previous years.

The green line shows the means of <u>cow</u> daughter fertility breeding values for all cows that <u>calved</u> by year of calving. Thus, for example, for cows born in 2000, the mean sire daughter fertility breeding value was 99.9 and the mean <u>cow</u> daughter fertility breeding value was 103.3. The mean <u>cow</u> daughter fertility breeding value for cows that calved in 2000 (green line) was 104.7. This is higher than both red and blue lines because these calvings on 2000 are by cows born in 1998 and earlier, thus cows with higher daughter fertility breeding values than those born in 2000. As sire and cow daughter fertility breeding values declined over time, the older cows had, on average, higher values than younger cows. Accordingly, the changes shown by the green line lag behind changes shown by the red and blue lines. Thus, the green line commenced increasing in 2017 and 2018, 6-7 years after 2011, the first year when cows born had higher cow daughter fertility breeding values than cows born in previous years.

Over a very long period of constant rate of increase in sire daughter fertility breeding values, the green line would be expected to become parallel to the blue and red lines, but with both the mean sire daughter fertility breeding values (blue line) and mean cow daughter fertility breeding values (maroon line) above the green line, as the incoming 2-year olds 'pull' the herd average up.

As a 1 unit increase in cow daughter fertility breeding values is expected to generate a 1 percentage point increase in 6-week in-calf rate, the small increases in the green lines for calvings in 2017 and 2018 would be expected to have caused only small increases in 6-week in-calf rates (0.3%) in those years. Such increases to 2018 are small when viewed in the context of 6-week in-calf rates being achieved (Table 2).However increases in sire daughter fertility breeding values will continue, possibly at greater rates than shown by the blue line, and so genetic improvement will result in slow but steady improvements in reproductive performance generally. In the next section, future rates of improvement in reproductive performance with two rates of increase in sire daughter fertility breeding values are explored.

Figure 2. Holstein-Friesian cows with atleast one calving immediately prior to a mating period with high quality reproductive data:

Blue line: Mean of all cows' sires' daughter fertility breeding values by cow's year of birth;

Maroon line: Mean of all cows' daughter fertility breeding values by cow's year of birth;

Green line: Mean of cows' daughter fertility breeding values for all calvings in year.

Table 2. Crude 6-week in-calf rates by year of calving within calving system for FFFF cows

Year	Seasonal		Split		Year-round	
	6-week in-calf rate	No. lactations	6-week in-calf rate	No. lactations	6-week in-calf rate	No. lactations
2000	48.3%	2912	37.1%	1005		0
2001	55.7%	4564	34.5%	890		0
2002	45.2%	7459	42.9%	3038	12.3%	219
2003	49.2%	6476	35.2%	2799	18.9%	418
2004	48.1%	6304	38.5%	3433	14.9%	1657
2005	47.3%	9220	41.9%	6652	21.5%	1411
2006	46.1%	12166	41.9%	7357	29.9%	555
2007	40.4%	15706	37.9%	6598	15.4%	2945
2008	43.8%	17863	41.7%	8311	19.1%	3344
2009	40.1%	12569	37.8%	8462	18.8%	2304
2010	48.5%	8774	39.2%	8450	23.7%	3245
2011	45.6%	10691	42.2%	9376	18.6%	1968
2012	42.8%	8040	39.0%	9332	14.2%	3444
2013	40.1%	14481	41.1%	18262	19.7%	12515
2014	41.3%	16346	41.4%	20704	21.0%	13898
2015	40.0%	15389	37.8%	19472	20.3%	12632
2016	37.4%	12009	39.5%	16178	21.6%	12474
2017	41.2%	9714	37.6%	14848	27.1%	8547
2018	44.8%	2723	40.6%	7836	25.3%	3963

Possible future rates of improvement in reproductive performance

The rate of increase in sire daughter fertility breeding value for cows born from 2011 to 2016 (the linear regression coefficient) was 0.61 units per year. Using this in a simple model with a herd age structure based on cows' year of birth for calvings in 2017 in the study dataset (Table 3), it is possible to get some idea about the mean cow daughter fertility breeding values for both cows born and for all calvings in 2019 and beyond. Such extrapolations were made to 2030 (Figure 3). These show that under those assumptions, an increase in 6-week in-calf rates of about 4% (ie 4 percentage points) by 2030 over 2018 performance would be expected. This is a relatively small increase given current 6-week in-calf rates (Table 2).

Extrapolations were also made assuming twice that rate of increase in sire daughter fertility breeding value (ie 1.22 units per year; Figure 4). These show that under those assumptions, an increase in 6-week in-calf rates of about 8% (ie 8 percentage points) by 2030 over 2018 performance would be expected. This would be a modest increase given current 6-week in-calf rates (Table 2).
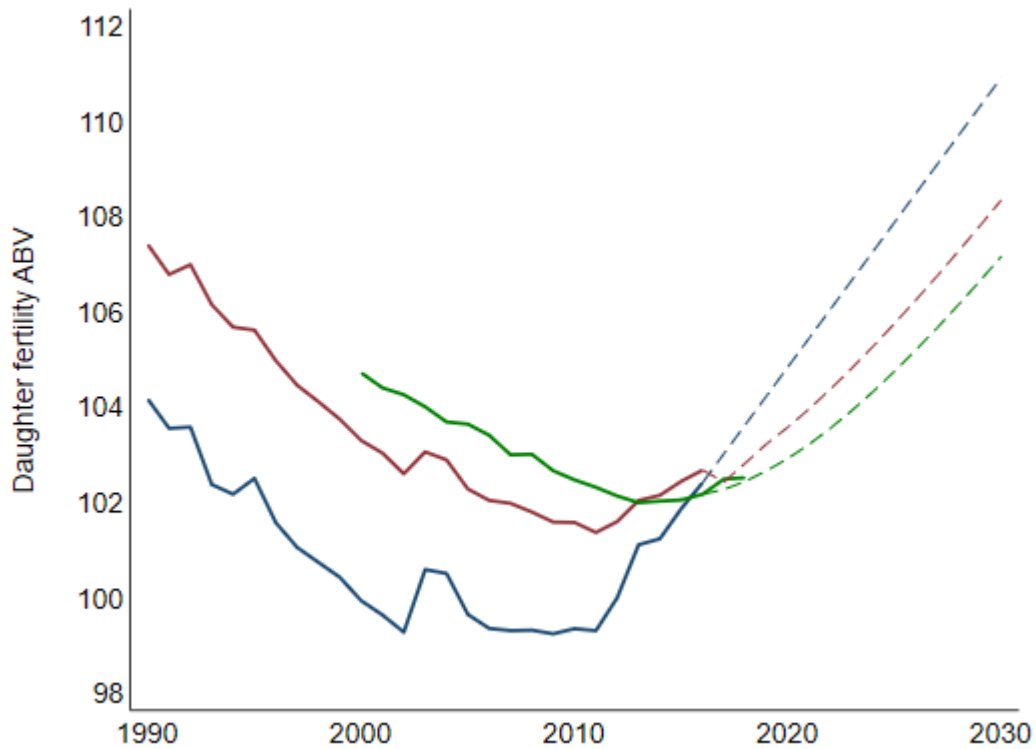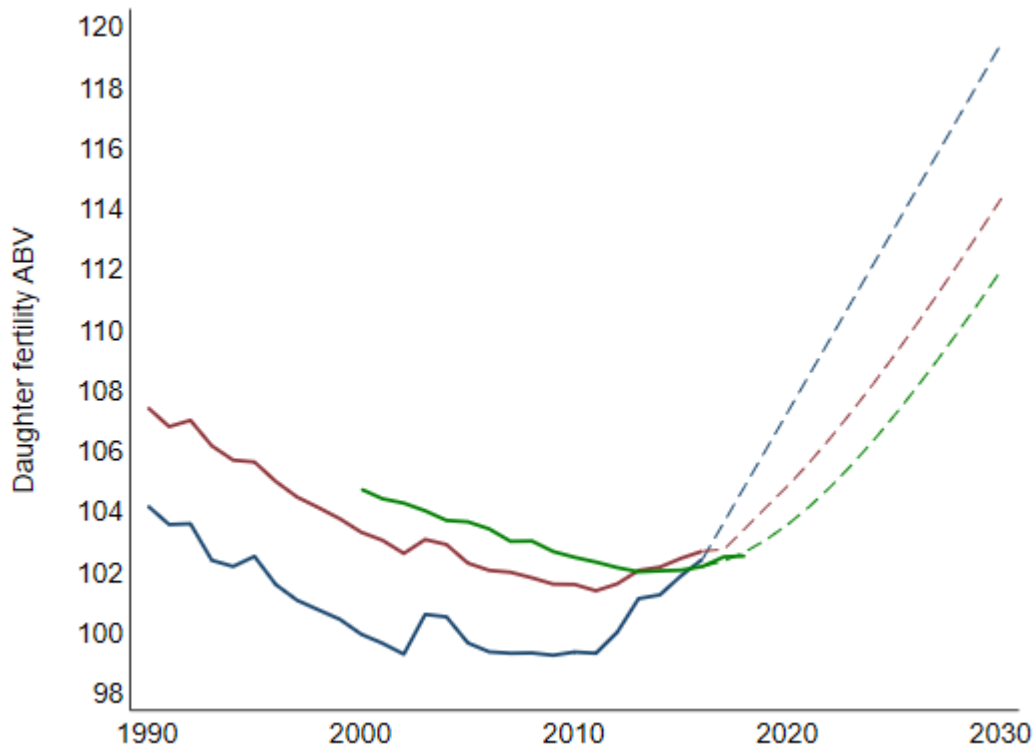
Figure 3. Holstein-Friesian cows with atleast one calving immediately prior to a mating period with high quality reproductive data:

Blue line: Mean of all cows' sires' daughter fertility breeding values by cow's year of birth;

Maroon line: Mean of all cows' daughter fertility breeding values by cow's year of birth;

Green line: Mean of cows' daughter fertility breeding values for all calvings in year.

Dashed lines are extrapolations assuming the mean of all cows' sires' daughter fertility breeding values continues to increase at 0.61 units per year.

Figure 3. Holstein-Friesian cows with atleast one calving immediately prior to a mating period with high quality reproductive data:

Blue line: Mean of all cows' sires' daughter fertility breeding values by cow's year of birth;

Maroon line: Mean of all cows' daughter fertility breeding values by cow's year of birth;

Green line: Mean of cows' daughter fertility breeding values for all calvings in year.

Dashed lines are extrapolations assuming the mean of all cows' sires' daughter fertility breeding values continues to increase at 1.22 units per year. Note that the y-scale has been extended to 120 (rather than an upper limit of 112 as in Figures 2 and 3).

Table 3. Distribution of calvings in 2017 by cow's year of birth in the study dataset

Cow year of birth	No. calvings	% calved	% calved disregarding those where cow was shown as being born in 2016-2019 or before 1999
1975	1	0.00%	
1988	1	0.00%	
1991	1	0.00%	
1992	1	0.00%	
1994	1	0.00%	
1995	3	0.00%	
1998	4	0.01%	
1999	2	0.00%	0.00%
2000	4	0.01%	0.01%
2001	14	0.02%	0.02%
2002	19	0.03%	0.03%
2003	37	0.06%	0.06%
2004	100	0.15%	0.15%
2005	207	0.31%	0.31%
2006	427	0.64%	0.64%
2007	842	1.26%	1.27%
2008	1597	2.39%	2.40%
2009	2686	4.02%	4.04%
2010	4170	6.24%	6.28%
2011	6332	9.48%	9.53%
2012	9132	13.67%	13.75%
2013	11228	16.81%	16.90%
2014	12977	19.42%	19.54%
2015	16653	24.93%	25.07%
2016	261	0.39%	
2017	106	0.16%	
2018	6	0.01%	

[1]The small numbers of calvings in 2017 apparently for cows born in 2016-2018 and before 1999 were disregarded when calculating assumed herd age structure, resulting in the structure shown in this column.