How much does genetic gain impact economic optimum productive life?

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Background: Why revisit optimum productive life?

- Optimum productive life varies widely in literature 3.8 – 7 years
  - Limited Australian examples

- The rate of genetic gain in Australian dairy herds has doubled since genomics introduced.
  - De Vries (2017) concluded accelerating genetic gain due to genomic selection has a minor effect on optimal productive lifespan → North American context

- **Hypothesis:**
  - Australian trends will align with overseas trends, impact of rate of genetic gain on optimum productive life will be small

Background: What is the variation in genetic gain in Australian herds?

- Calculated within herd rate of genetic gain using Balanced Performance Index (BPI), DataGene Dec 2025
- Holstein cows born 2019-2023 inclusive
- Filter (no. 1085):
  - ≥10 cows per herd-year-breed
  - ≥3 years of data
  - BPI change within ±3 SD of mean

25% of Holstein herds rate of genetic is between $54 & 112/cow/year

Table. Average rate of genetic gain(st.dev); BPI units($/cow/year) and standard deviation units of the BPI (SD index)

Units	mean	Median	IQR	max
$AU/cow/year	38.5 (23.9)	40.6	26.7 - 53.5	112.1
SD index	0.34 (0.21)	0.36	0.23 - 0.47	0.99

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Method overview

- Deterministic model in Excel
- Models from lactation 1-10, assuming all cows culled in 10th lactation
  - Lactation specific inputs
- Involuntary culling **fixed**
  - Cows culled before 240 days in milk
  - Cows who died
- Voluntary culling – rate varied to find where optimum productive life occurs
  - Each lactation represented as deviation from total voluntary cull rate (different across age groups)

- Assumptions:
  - Voluntary culling based on milk production
  - Herd in a steady state (no change to herd size)
  - 1 lactation = 1 year
  - 1 year timeframe

Data

- 5 Financial years: July 2019 – June 2024
  - ABVs & Herd test statistics (DataGene)
  - Dairy Farm Monitor Project data extracted from Dairy Base (1190 herd-years)
    - Farm physical & financial benchmarking data
  - Historical cattle auction records
  - All financial data adjusted for inflation & converted to real time (23/24FY) values

Metric	Value ($AU/cow)
Profit (earnings before interest and tax)	1167
Milk Income	4936
Feed Costs	2337
Cull cow salvage value	1199
Heifer rearing	2099

Method: Adjustments for each lactation

$Profit_{AdjLac}$= Profit + Genetic gain + Maturity cost + Aging cost + Replacement cost + Calf opportunity cost + Voluntary culling

- ***Genetic Gain,*** $/cow/year. Lactation 10 animals were the base, with younger lactations assigned higher genetic merit according to rate of genetic gain.

- ***Maturity effects:*** 85% of mature cow production in Lactation 1, 95% in lactation 2

- ***Aging Cost:*** As cows age, milk production decreases & costs increase.
  - Performance reduced to 95%, 90% and 85% of baseline in lactations 6, 7 and 8+, respectively

Method: Adjustments for each lactation

$Profit_{AdjLac}$= Profit + Genetic gain + Maturity cost + Aging cost + Replacement cost + Calf opportunity cost + Voluntary culling

- ***Replacement cost:*** cost of rearing replacements minus income from cull cow sales
- ***Calf opportunity cost:*** change to number of non-replacement calves for sale
- ***Voluntary culling:*** Assumed based on milk production.
  - $\$V_i = SI_l \times R \times (SD)$
    - SI, Selection intensity = defined by voluntary culling rate
    - R, Repeatability= 0.5
    - SD, standard deviation (milk income over feed costs $468)

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Method: Scenario testing

- Populated model with national average data
- Vary voluntary culling rate to find where optimum productive life occurs
- Sensitivity analysis of key assumptions:

Variable	Change considered
Genetic Gain ($AU /cow/yr)	0, 15, 30, 40, 50, 65, 80, 100
Milk Income	±30%
Heifer replacement costs	±30%
Feed costs[2]	±50%

[2]Assumed to impact cow feed costs and feed costs of replacements

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Table. Point where economic optimum productive occurs for a given rate of genetic gain

National average

Genetic Gain $/cow/yr (SD index units)	**0**	**15** (0.13)	**30** (0.26)	**40** (0.35)	**50** (0.44)	**65** (0.57)	**80** (0.70)	**100** (0.88)
Productive Life (years)				4.13				
Replacement rate				0.24				
Vol cul rate				0.12				
PROFIT ($/COW)				1026				

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Table. Point where economic optimum productive occurs for a given rate of genetic gain

~50% of Holstein between $30&65/cow/year →
0.23 lactation difference in productive life

Genetic Gain $/cow/yr (SD index units)	0	15 (0.13)	30 (0.26)	40 (0.35)	50 (0.44)	65 (0.57)	80 (0.70)	100 (0.88)
Productive Life (years)	4.42	4.42	4.13	4.13	4.13	3.87	3.64	3.64
Replacement rate	0.23	0.23	0.24	0.24	0.24	0.26	0.27	0.27
Vol cul rate	0.10	0.10	0.12	0.12	0.12	0.14	0.16	0.16
PROFIT ($/COW)	766	863	961	1026	1092	1193	1293	1430

0.78 lactation difference between
$0 and $100 rate of genetic gain

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Table. Point where economic optimum productive occurs for a given rate of genetic gain

Genetic Gain $/cow/yr (SD index units)	**0**
Productive Life (years)	4.42
Replacement rate	0.23
Vol cul rate	0.10
PROFIT ($/COW)	766
Adjustments	
Voluntary culling	108
Genetic lag	0
Aging	-103
Maturity	-214
Replacement	-169
Calf	-23

Assume no genetic gain maturity has biggest impact

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Results

Table. Point where economic optimum productive occurs for a given rate of genetic gain

Genetic Gain $/cow/yr (SD index units)	**0**	**15** (0.13)	**30** (0.26)	**40** (0.35)
Productive Life (years)	4.42	4.42	4.13	4.13
Replacement rate	0.23	0.23	0.24	0.24
Vol cul rate	0.10	0.10	0.12	0.12
PROFIT ($/COW)	766	863	961	1026
Adjustments				
Voluntary culling	108	108	122	122
Genetic lag	0	96	197	263
Aging	-103	-103	-92	-92
Maturity	-214	-214	-228	-228
Replacement	-169	-169	-181	-181
Calf	-23	-23	-24	-24

$40/year genetic gain had the biggest effect

Assume no genetic gain maturity has biggest impact

$15/year genetic gain had the second smallest effect.

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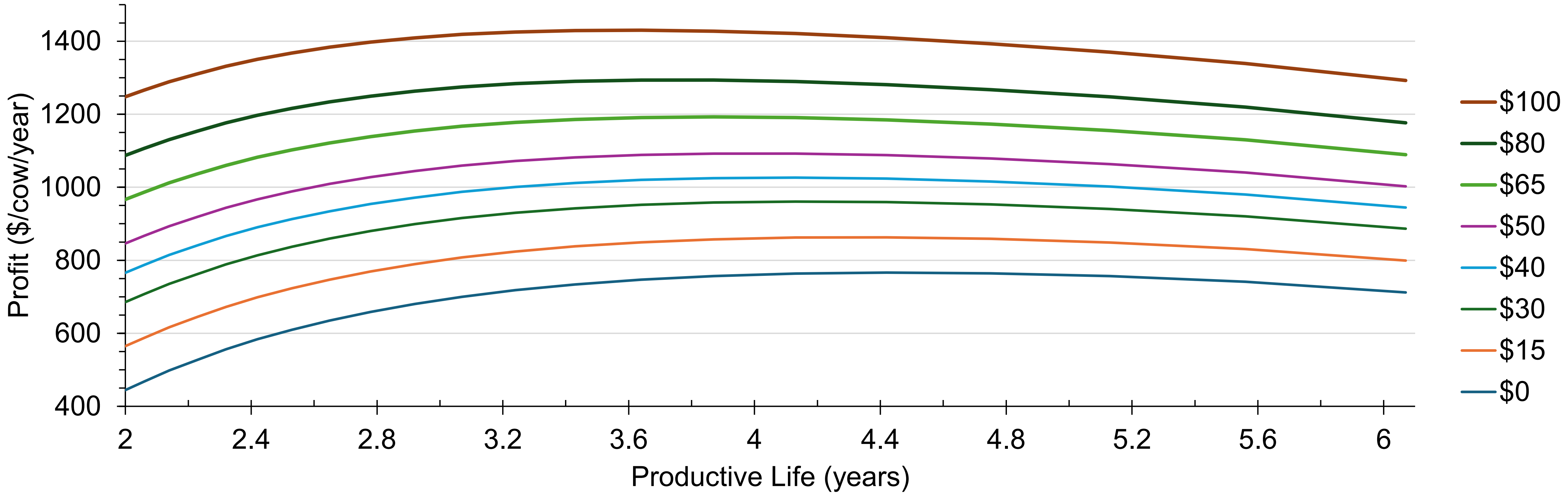
Fig 1. Effect of changing voluntary culling rate on profit for differing rates of genetic gain.



- Close to economic optimum for a range of productive life
- Changing culling rate ± 4% of where optimum occurred, changed profit up to $AU 14/cow
- Benefit of changing herd productive life is likely to be marginal (unless productive life is very extreme)

Sensitivity Analyses

	How does changing input values impact where optimum occurs?	Does changing input values change the size of effect genetic gain has
Scenario	**Main effect on optimum productive life (lactations)**	**Effect of genetic gain on optimum productive life (lactations)**
National average	Average 4.1 lactations; Range: 4.4 to 3.6	0.8 lactations

Sensitivity Analyses

	How does changing input values impact where optimum occurs?	Does changing input values change the size of effect genetic gain has
Scenario	**Main effect on optimum productive life (lactations)**	**Effect of genetic gain on optimum productive life (lactations)**
National average	Range: 4.4 to 3.6	0.8 lactations
Replacement cost −30%	↓ up to 0.7 lactations	
Replacement cost +30%	↑up to 0.8 lactations	

Sensitivity Analyses

How does changing input values impact where optimum occurs?

Does changing input values change the size of effect genetic gain has

Scenario	Main effect on optimum productive life (lactations)	Effect of genetic gain on optimum productive life (lactations)
National average	Range: 4.4 to 3.6	0.8 lactations
Replacement cost −30%	↓ up to 0.7 lactations	
Replacement cost +30%	↑up to 0.8 lactations	
Feed costs −50%	↓up to 1.2 lactations	
Feed costs +50%	↑ up to 1.4 lactations	

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Sensitivity Analyses

	How does changing input values impact where optimum occurs?	Does changing input values change the size of effect genetic gain has
Scenario	**Main effect on optimum productive life (lactations)**	**Effect of genetic gain on optimum productive life (lactations)**
National average	Range: 4.4 to 3.6	0.8 lactations
Replacement cost −30%	↓ up to 0.71 lactations	
Replacement cost +30%	↑up to 0.8 lactations	
Feed costs −50%	↓up to 1.2 lactations	
Feed costs +50%	↑ up to 1.4 lactations	
Milk income −30%	↑ up to 1.1 lactations	
Milk income +30%	↓0.5 lactations	

Sensitivity Analyses

How does changing input values impact where optimum occurs?

Does changing input values change the size of effect genetic gain has

Scenario	Main effect on optimum productive life (lactations)	Effect of genetic gain on optimum productive life (lactations)
National average	Range: 4.4 to 3.6	0.8 lactations
Replacement cost −30%	↓ up to 0.71 lactations	Similar
Replacement cost +30%	↑up to 0.8 lactations	
Feed costs −50%	↓up to 1.2 lactations	
Feed costs +50%	↑ up to 1.4 lactations	
Milk income −30%	↑ up to 1.1 lactations	1.7 lactations (Range: 3.9 to 5.6)
Milk income +30%	↓0.5 lactations	0.7 lactations

Summary

- Using national average data, varying genetic gain from $0 to $100/cow/year changed optimum productive life from 4.42 – 3.64 lactations (0.78 lactations)
  - Optimum productive life within range observed in literature
  - Agrees with overseas literature genomics has had relatively small effect on optimum

- Impact of rate of genetic gain on optimum productive life increased from 0.78 lactations to 1.69 lactations when milk income decreased by 30% (little difference for other inputs)
  - Are situations where effect of rate of genetic gain on optimum productive life is larger

Conclusions

- Herd's optimum productive life influenced by range of factors
  - Important to consider these.
  - Where optimum occurred was most sensitive to decreases in milk income.
  - Next steps additional sensitivity analyses including different feeding systems.

- Productive life nearly optimised over a range of values.
  - Slope of profit curves near optimum is relatively flat.

- Implication for farmers is that benefits of changing herd average productive life are likely to be marginal (unless productive life or genetic gain is very extreme)

Acknowledgements

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