Selection for Lower Methane Livestock

Selection Index Considerations

Julius van der Werf
University of New England
Armidale NSW Australia

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ICAR Feed and Gas working group and the ASGGN Genetics network of the Global Research Alliance Livestock research group

Selection for lower methane livestock

What is needed?

- **Phenotypes:** building a reference population so we can use genomic prediction
- **Genetic Parameters** with other important traits - Including Feed Intake
- **A selection strategy**
  - Define a breeding objective
  - Define a selection index
  - Communication with breeder, producers, other stakeholders

Selection for lower methane livestock

A selection strategy

– Define a breeding objective

- Which traits? methane production per head?, methane intensity?, methane yield?, profit vs methane?
- What weightings economic?, desired gains?, emissions cap/quotum?
- What perspective? optimize per animal?, per farm, per ha?, per unit of product?, per country?

– Define a selection index

- Which traits?
- What weightings

Would be good to somewhat agree on an approach

Selection for more methane efficient livestock

Aim is to produce less methane from cattle/sheep

Akin to using less feed resources → Feed efficiency

Using fewer emissions / resources
to produce the animal food that we want

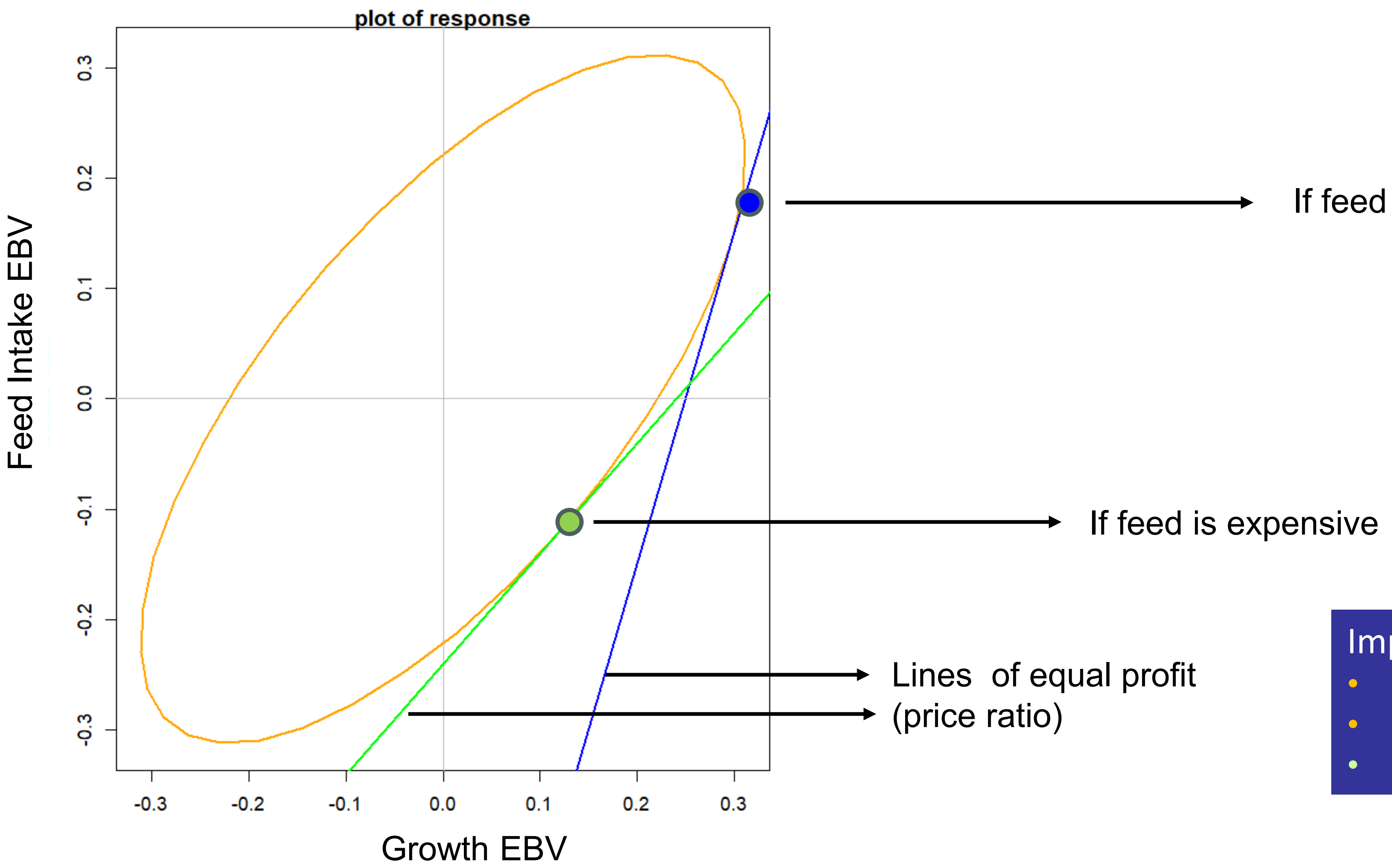
<u>Defining the trait:</u>	with feed we have	with methane
• Feed Intake (per head)	How much they eat	Methane Production (per head)
• Feed Efficiency	How much they grow per kg of feed	Methane intensity (CH4/unit of product)
• Feed Conversion rate	How much they eat per kg of growth	Methane Yield (CH4 per kg DMI)
• Residual Feed Intake	Correct intake for how much they grow	Residual Methane

But note: Feed resources maybe limited
but emission will have to reduce

We have a framework for Multiple Trait Selection to find an (economic) optimum

Selecting for growth and feed intake (linear index)

Br.Obj. = v_1 BV_1 + v_2 BV_2
Index = v_1 EBV_1 + v_2 EBV_2

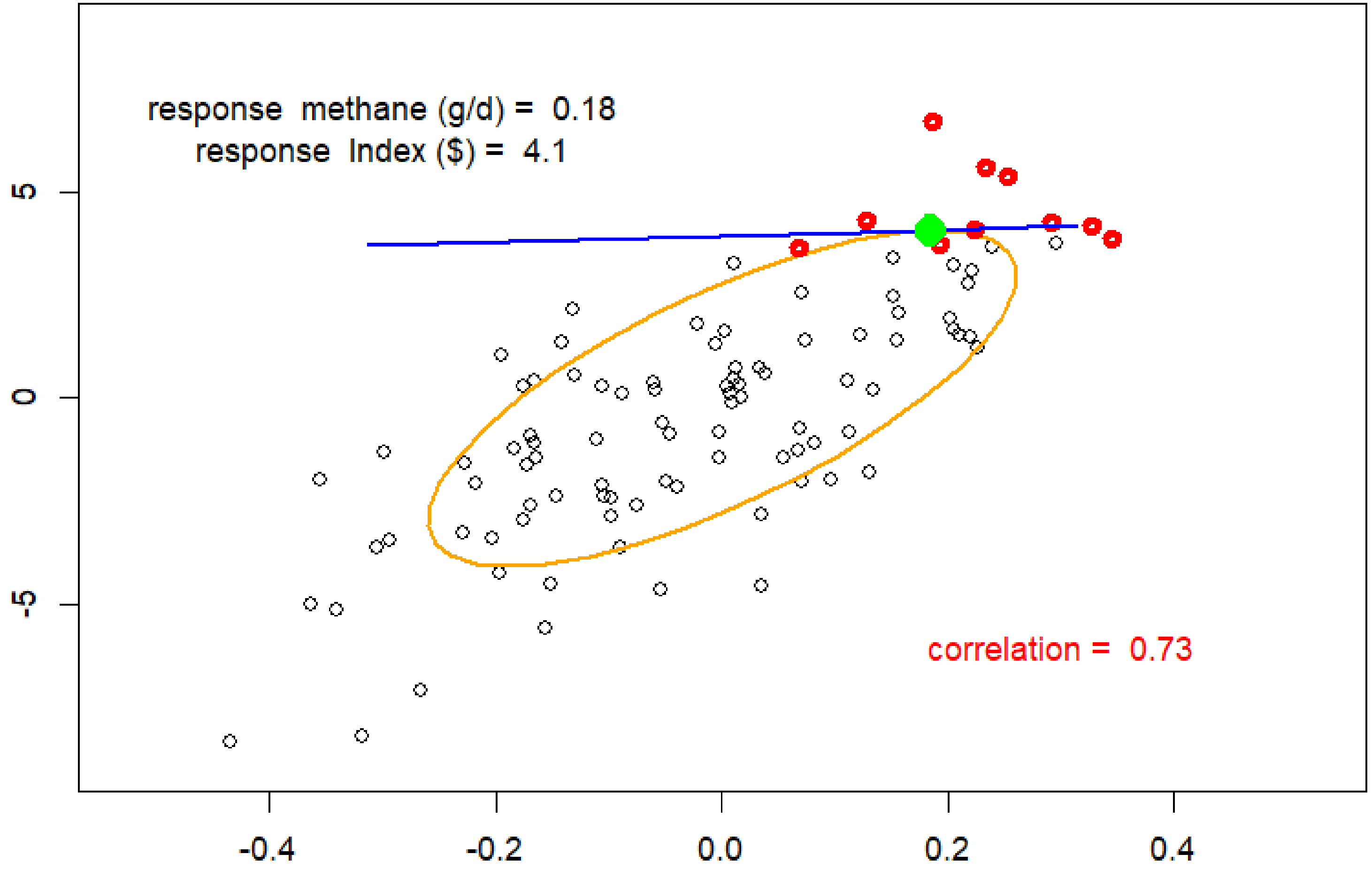


Important parameters:

- Variation in EBV
- Correlation between EBVs
- Ratio of econ weights

We can apply a similar approach to methane vs all other traits ($index)

Carbon price is $40/tonne



Index ($)

Methane EBV

axes show response per year (in sheep)

Important parameters:

- Variation in EBV
- Correlation between EBVs
- Ratio of econ weights

1. Correlation between methane and production (index) is key
2. Current economic value for methane is not going to have an effect

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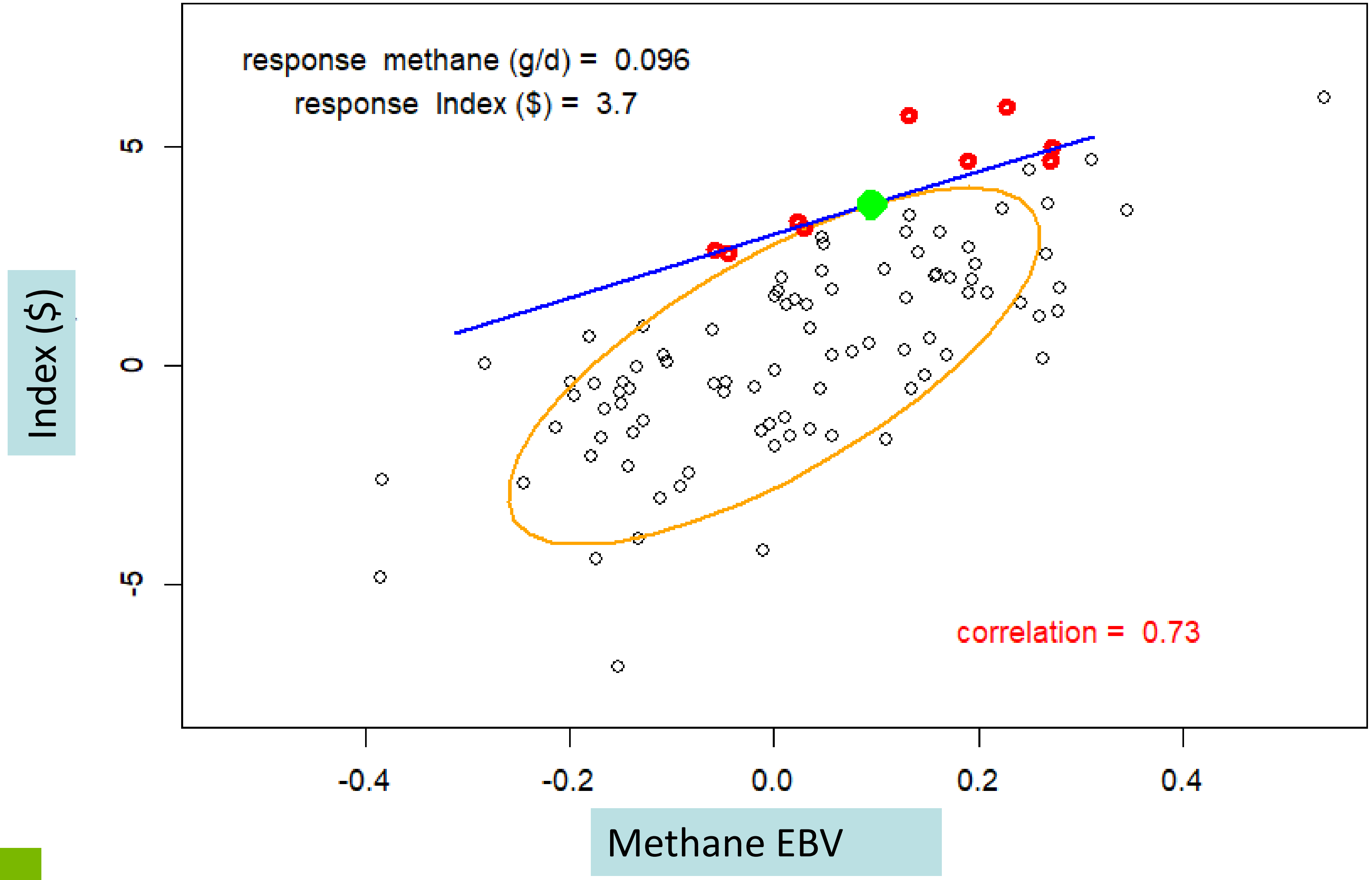
We can put **more weight** on methane vs all other traits ($index)

Carbon price is $400/tonne



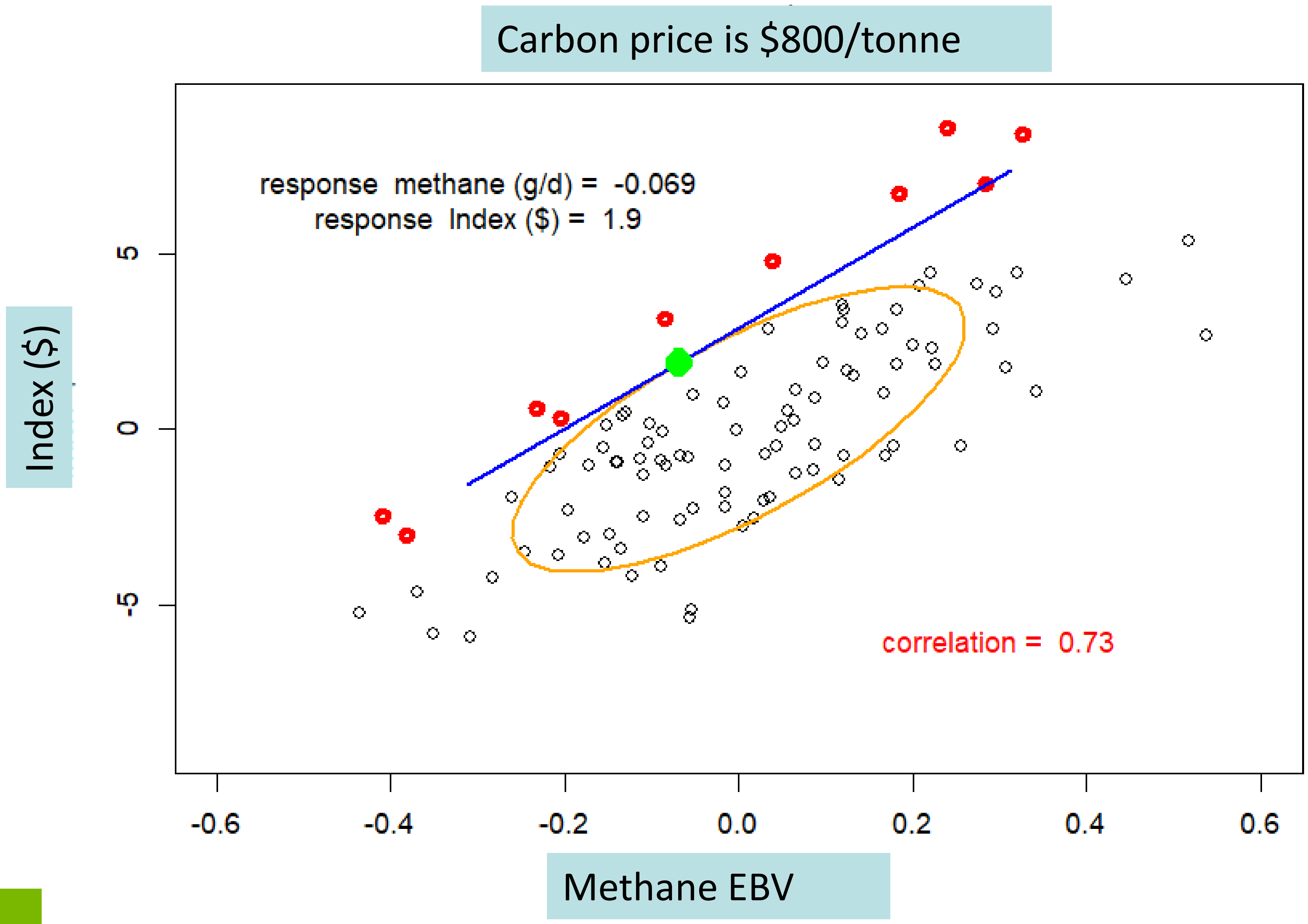
axes show response per year (in sheep)

carbon price	Index $ response	Methane resp per head
$40	$4.10	0.18
$400	$3.70	0.10

- There will be a cost
- Less so with lower correlation

We can put **even more weight** on methane vs all other traits ($index)

axes show response per year
(in sheep)



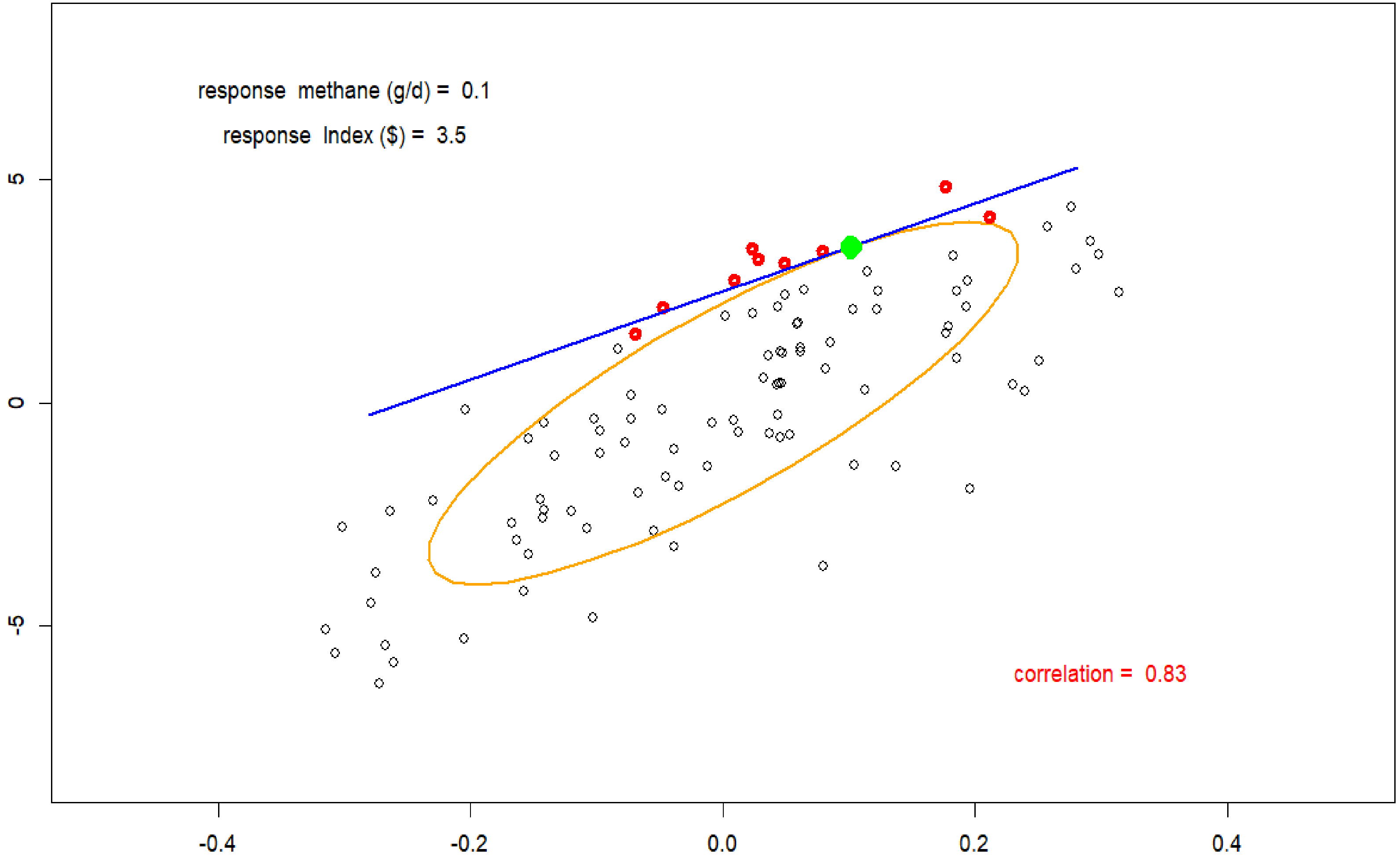
carbon price	Index $ response	Methane resp per head
$40	$4.10	0.18
$400	$3.70	0.10
$800	$1.90	-0.07

- There will be a cost
- Less so with lower correlation

- At some point we would loose the “sweet spot”

No info on methane requires more weight on methane vs all other traits ($index)

Carbon price is $550/tonne



Index ($)

Methane EBV

axes show response per year (in sheep)

carbon price	Index $ response	Methane resp per head
$40	$4.10	0.18
$400	$3.70	0.10
$550	$3.50	0.10

if methane not measured

- There will be a cost
- Less so with lower correlation

- Not measuring methane effectively increases correlation between EBVs
  (here from 0.73 to 0.83)

But do we need to worry about methane per head?

Traits:

How about methane intensity?
Methane yield?
Residual methane

Perspective:

Optimise per head profit / productivity / feed / methane
Per ha
Per kg product
Per country

Genetic change per year

Model for Australian Sheep (lamb production)

	current mean	select for profit	
		trait change	$value
Slaughter Weight (9 mo)	47.3	0.88	$2.68
Eye Muscle Depth mm	28	0.29	$1.12
Fertility (preg rate)	0.75	0.01	$1.11
Lambing rate)	1.5	0	$0.31
Mature ewe Weight	55	0.98	$0.74
Daily DM Feed Intake (kg)	1.2	0.01	-$1.82
Methane production (g/day)	24	0.16	-$0.12
Index			$4.35
change in methane per ewe		0.68%	
total flock CO2 Eqvt tonne/yr	43.0	43.5	1.10%
kg CO2Eqvt per kg lamb produced	22.6	22	-2.60%

Genetic change per year for different sheep breeding objectives

	current mean	select for profit: trait change	select for profit: $value	reduce methane per head: trait change	reduce methane per head: $value
Slaughter Weight (9 mo)	47.3	0.88	$2.68	-0.82	-$2.49
Eye Muscle Depth mm	28	0.29	$1.12	-0.19	-$0.71
Fertility (preg rate)	0.75	0.01	$1.11	-0.01	-$1.41
Lambing rate)	1.5	0	$0.31	-0.01	-$0.42
Mature ewe Weight	55	0.98	$0.74	-1.12	-$0.84
Daily DM Feed Intake (kg)	1.2	0.01	-$1.82	-0.02	$3.15
Methane production (g/day)	24	0.16	-$0.12	-0.3	$0.21
Index			$4.35		-$2.73
change in methane per ewe		0.68%		-1.25%	
total flock CO_2 Eqvt tonne/yr	43.0	43.5	1.10%	42.2	-1.80%
kg CO_2Eqvt per kg lamb produced	22.6	22	-2.60%	23.16	2.50%

Assumed high correlation between methane and feed intake

Genetic change per year for different sheep breeding objectives

	current mean	select for profit: trait change	select for profit: $value	reduce methane intensity: trait change	reduce methane intensity: $value
Slaughter Weight (9 mo)	47.3	0.88	$2.68	0.74	$2.25
Eye Muscle Depth mm	28	0.29	$1.12	0.11	$0.42
Fertility (preg rate)	0.75	0.01	$1.11	0.01	$1.84
Lambing rate)	1.5	0	$0.31	0.01	$0.49
Mature ewe Weight	55	0.98	$0.74	1.11	$0.83
Daily DM Feed Intake (kg)	1.2	0.01	-$1.82	0.01	-$2.44
Methane production (g/day)	24	0.16	-$0.12	0.11	-$0.08
Index			$4.35		$3.17
change in methane per ewe		0.68%		0.44%	
total flock CO_2 Eqvt tonne/yr	43.0	43.5	1.10%	43.49	1.20%
kg CO_2Eqvt per kg lamb produced	22.6	22	-2.60%	21.8	-3.50%

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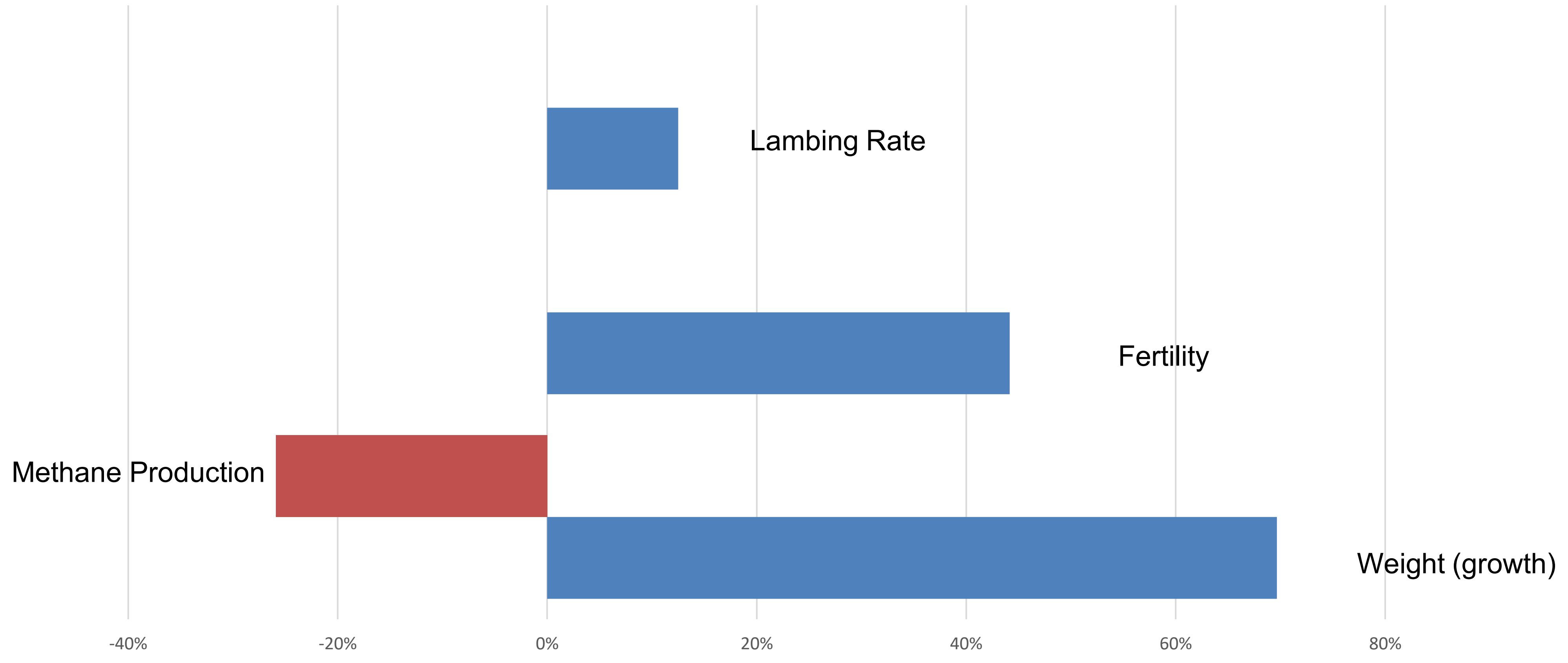
Productivity improvements contribute a lot to improving intensity

Trait contribution to methane reduction kg CO2 Eqvt /kg lamb meat



Perspective: What does it mean for the Australian sheep flock?

20 years of selection response

With fixed flock size

	Current	↑ profit/ head 2050	↓ methane/ head 2050	↓ methane intensity 2050
Nr breeding ewes (M)	35	35	35	35
lamb produced (10^3 tonne)	666	1,187	104	1,315
feed eaten (M-tonnes)	21.75	28.96	10.97	32.30
CO2 Eqvt MT/yr	**15.04**	**18.50**	**9.57**	**18.62**

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What does it mean for the Australian sheep flock?

With fixed flock size

20 years of selection response
Volume after selection for..

	Current Vol	↑ profit/head 2050 Vol	↓ methane/head 2050 Vol	↓ methane intensity 2050 Vol
Nr breeding ewes (M)	35	35	35	35
lamb produced (10^3 tonne)	666	1,187	104	1,315
feed eaten (M-tonnes)	21.8	29.0	11.0	32.3
CO2 Eqvt MT/yr	**15.04**	**18.50**	**9.57**	**18.62**

With cap on total methane (33% reduction)

20 years of selection Response
Volume after selection for…

	Current Vol	no selection 2050	↑ profit/head 2050	↓ methane/head 2050	↓ methane intensity 2050
Nr breeding ewes (M)	35	23	19	37	19
lamb produced (10^3 tonne)	666	443	642	108	706
feed eaten (M-tonnes)	21.8	14.5	15.7	11.5	17.3
CO2 Eqvt MT/yr	**15.0**	**10.0**	**10.0**	**10.0**	**10.0**

Which traits to select on?

Traits:

How about methane intensity?	Ratio Trait
Methane yield?	Ratio Trait
Residual methane	Conditional Trait

Conditional trait: Selection on production and feed intake == Selection on production and residual feed intake

just need to adjust economic values and parameters

Ratio Trait: Generally, less efficient or even a bad idea to include these in index or breeding objective (see next)

but could assess alternative options based n such efficiency parameters

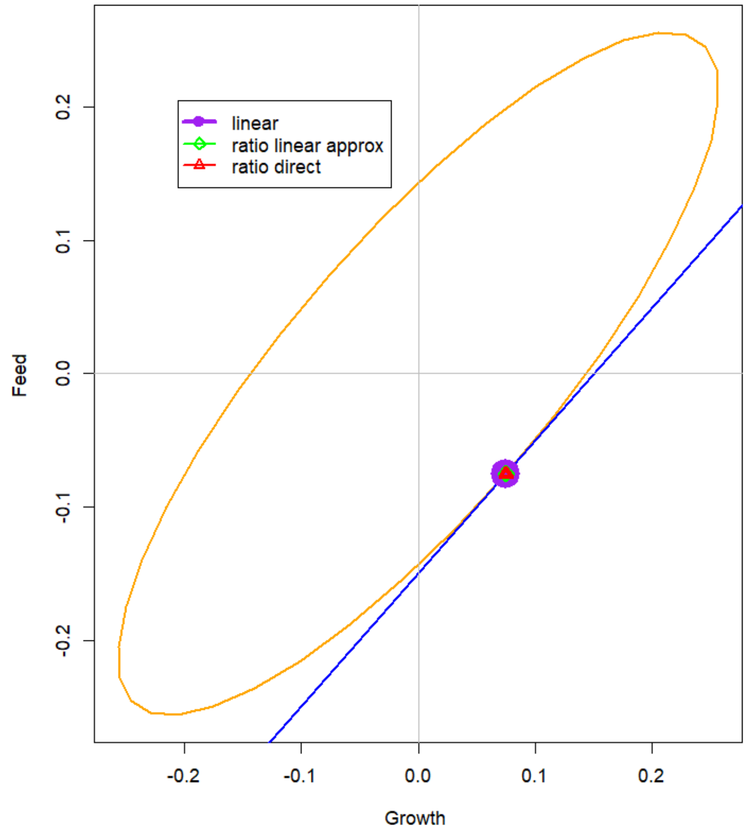
Using a ratio as the breeding goal

- A breeding objective defined as a ratio x/y is equivalent to a linear objective with economic weights μ_y and $-\mu_x$ for traits x and y, respectively

$$\frac{\partial(\frac{\mu_x}{\mu_y})}{\partial x} = \mu_y^{-1} \qquad \text{and} \qquad \frac{\partial(\frac{\mu_x}{\mu_y})}{\partial y} = -\mu_x \mu_y^{-2}$$

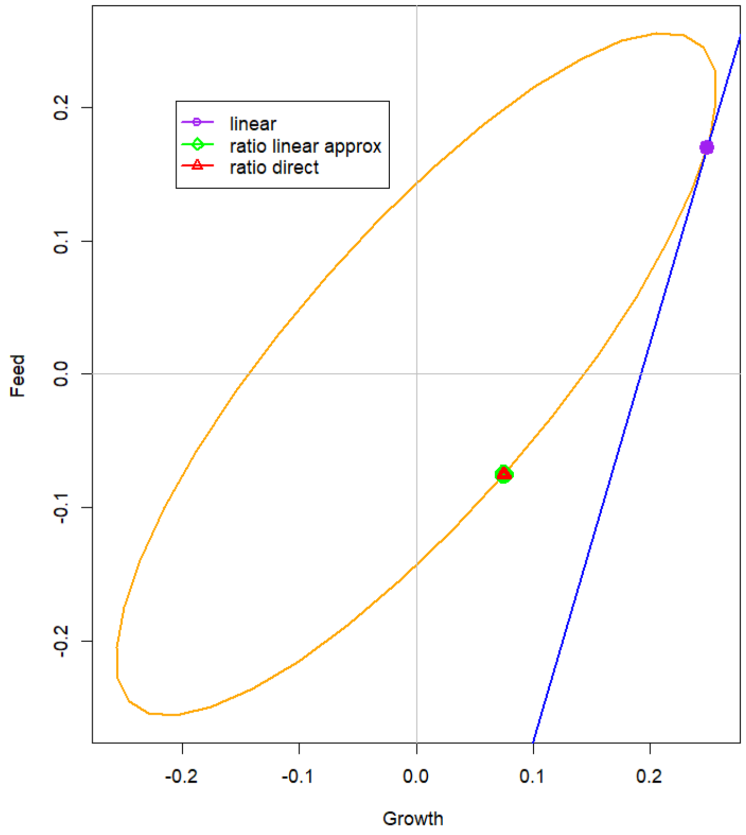
- So, weights in breeding objective are determined by means of component traits, not by economics or desired gains

Problems with selecting on a ratio > does not depend on econ weight



	Growth	Feed
CV	0.1	0.1
h^2	0.25	0.25
μ	10	10
EconVal	1	-1

all are same



Economic Objective

Ratio Objective

	Growth	Feed
CV	0.1	0.1
h^2	0.25	0.25
μ	10	10
EconVal	3	-1

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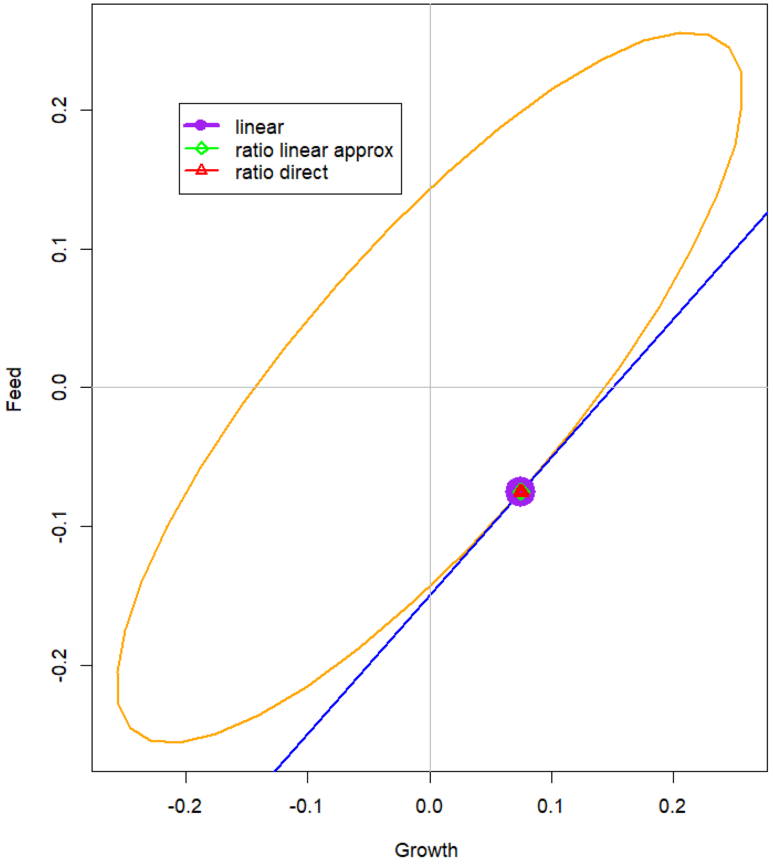
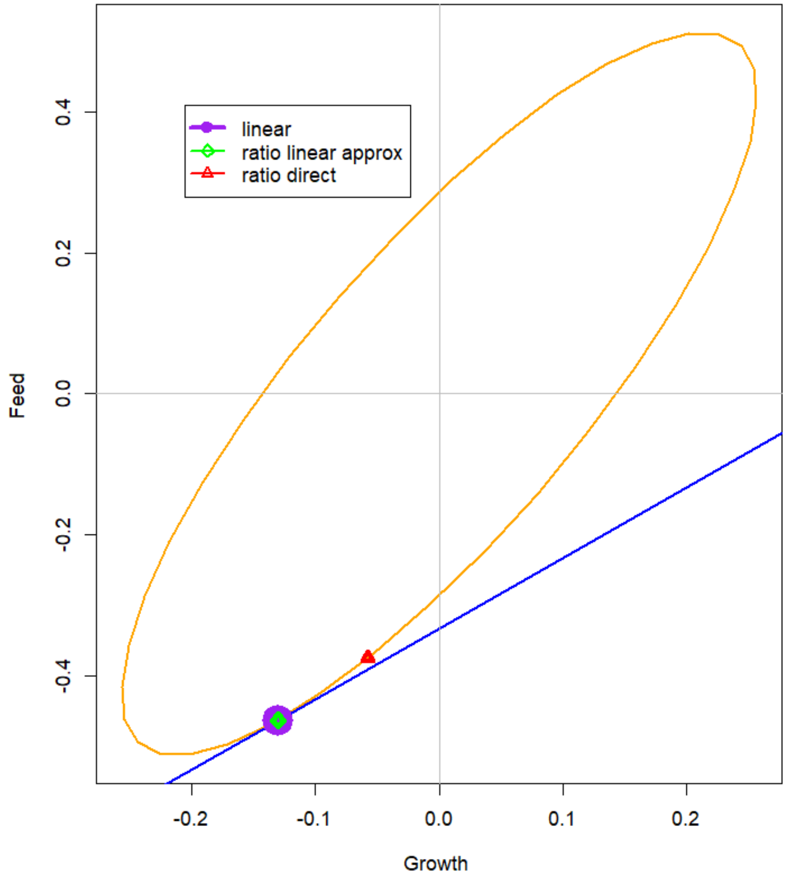
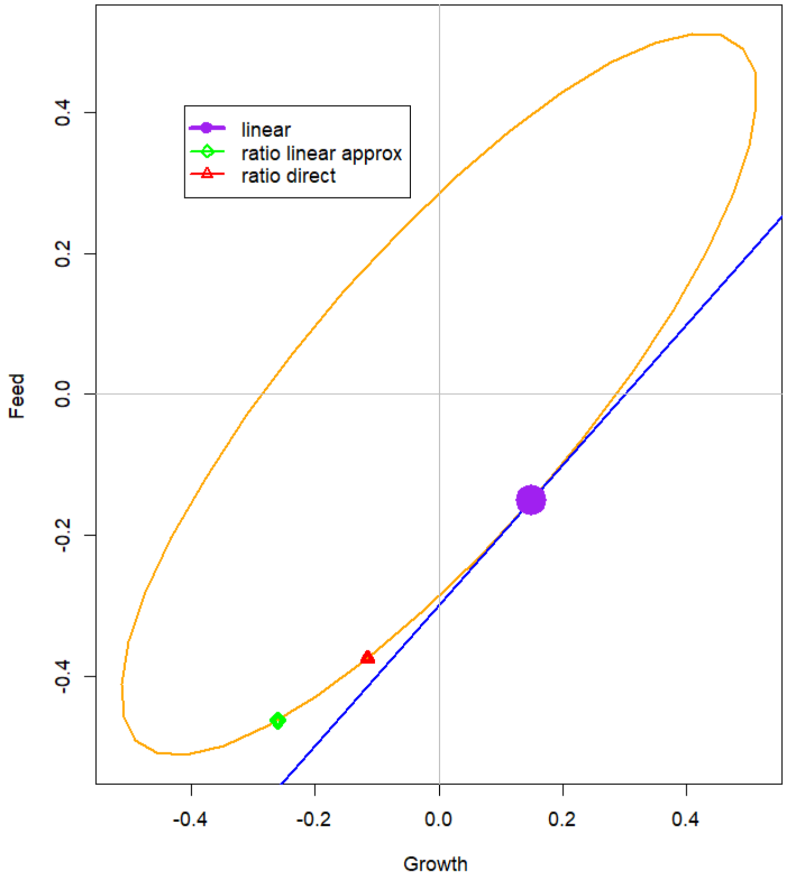
Problems with selecting on a ratio (depends on CV of traits)



	Growth	Feed	
CV	0.1	0.1	all are
h^2	0.25	0.25	same
μ	10	10	
EconVal	1	-1	

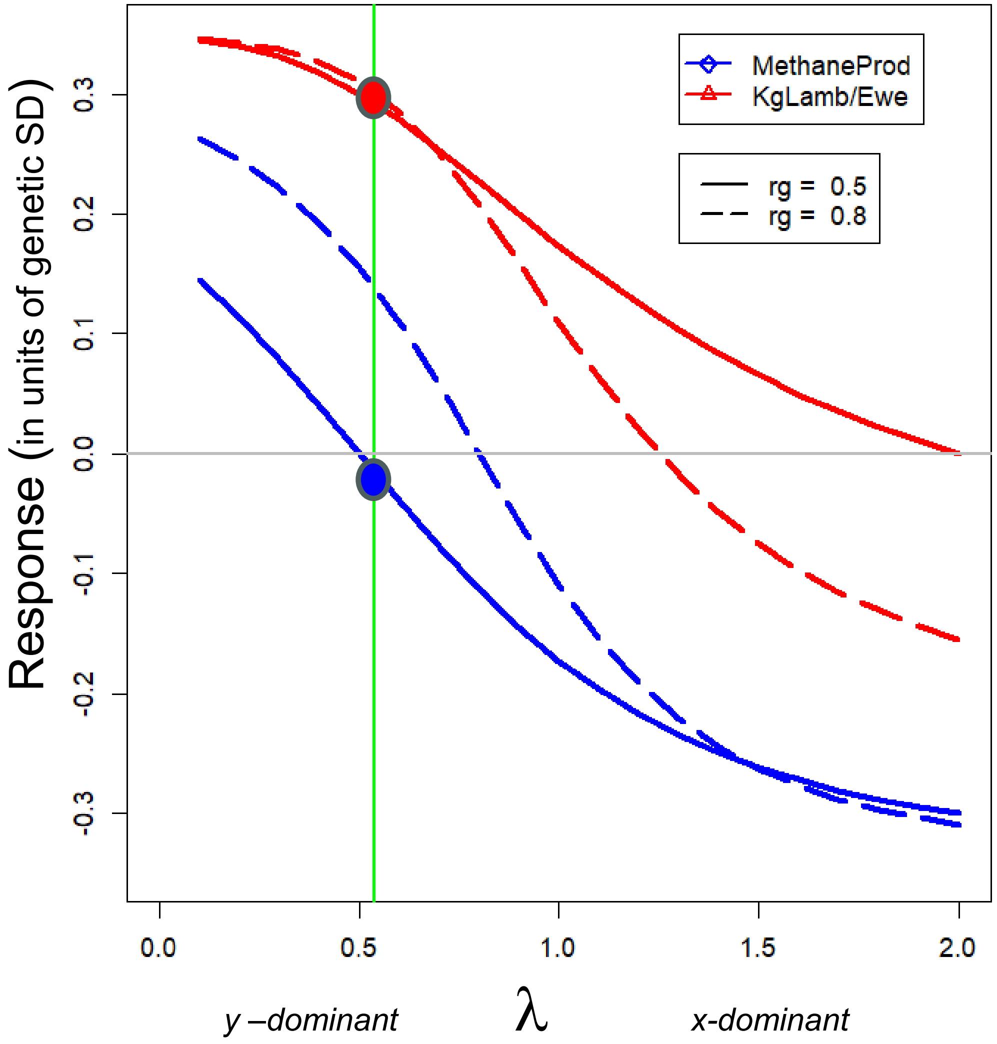


	Growth	Feed
CV	0.1	0.2
h^2	0.25	0.25
μ	10	10
EconVal	1	-1



	Growth	Feed
CV	0.1	0.2
h^2	0.25	0.25
μ	20	10
EconVal	1	-1

Response to selecting on ratio



Example: Methane intensity

= Methane / Kg Lamb per Ewe

nominator (Kg Lamb per Ewe) has a higher genetic coefficient of variation: $\lambda \cong 0.55$

Response to selection:

Mainly increasing Kg Lamb/ewe,

Methane change limited if r_g =0.5
Methane also going up if r_g =0.8

$\lambda = va_x / va_y$ is ratio of genetic coefficients of variation

Conclusion about ratio traits

As an objective trait

Equivalent as selection on ratio of means

Not economically optimised

Hard to manipulate by desired gains

As in index trait

Hard to control response, as it is determined by the ratio of genetic coefficients of variation

It is not even most efficient if ratio was the objective

Methane in objective but not in index (there is no data or EBV)

1. Weight of a trait is economic weight + carbon price * (effect on carbon)

   a) Account for correlated response via adjusting economic values
      - E.g objective = Protein, EV = $6 EV Corrected for FI : $6 +0.5*(-$4) 0.5 = correlation; - $4 = econ value feed

   b) If FI in breeding Objective: EV Protein = $6, EV FI = -$4. Response = $Resp_{protein}$ + $CorResp_{FI}$*-$4.

2. Weight = economic weight + carbon price * (effect on intensity) (Amer, 2018)

Summary

- Reduce animal methane emissions mainly through improvement of production (and reproduction) efficiency.
- A linear index is the easiest and most transparent approach
- Methane (and feed intake) per head are simplest approach (when EBVs are available
- need to determine a relative weight (likely driven by desired response) and use a systems perspective