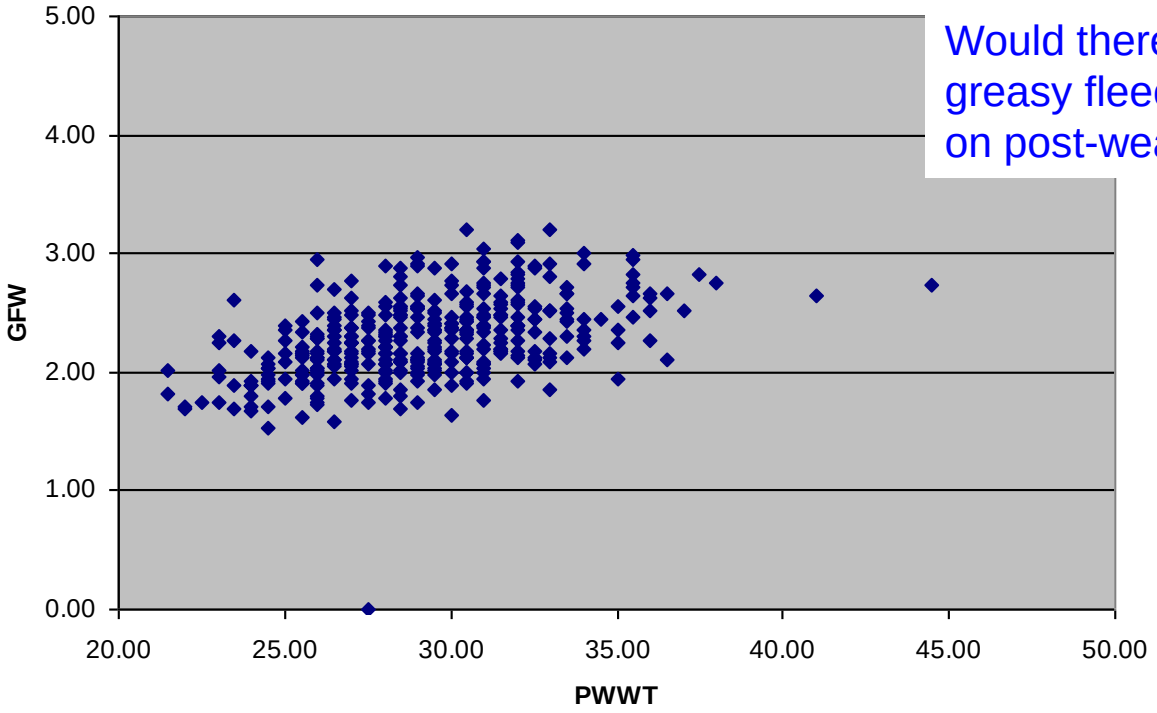
University of New England

Genetic change to multiple traits

Response and Correlated Response to Selection



Would there be any genetic response in greasy fleece weight (GFW) when selecting on post-weaning weight (PWWT)?

Yes, assuming a genetic correlation between GFW and PWWT exists

No if the observed phenotypic correlation is all due to environmental effects

Real-life breeding objectives

- In general breeders want to select for more than one trait simultaneously, a *multiple trait breeding objective*

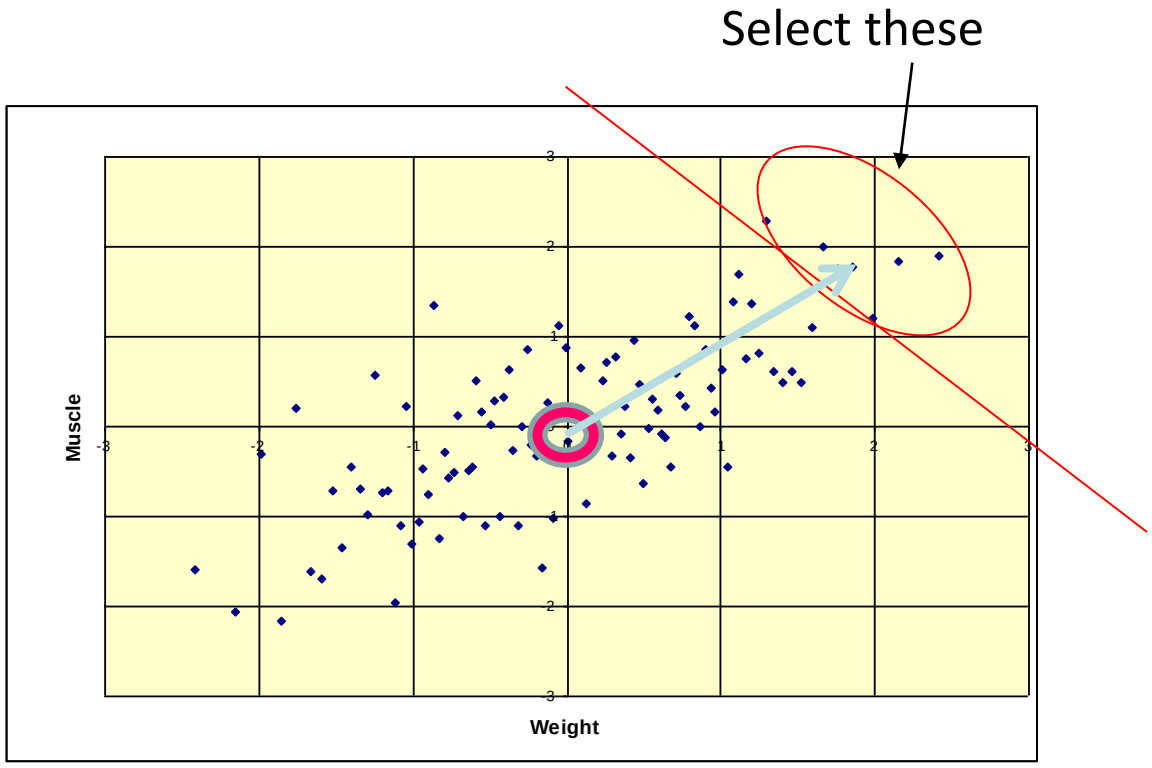
- For example
  - *Meat sheep:* increase growth, muscle and fat
  - *Dairy:* increase milk yield, fat, protein content and fertility

- Multiple trait selection utilizes the concept of selection indexes

Multiple trait selection: can we go anywhere we want?

Some correlations are favourable

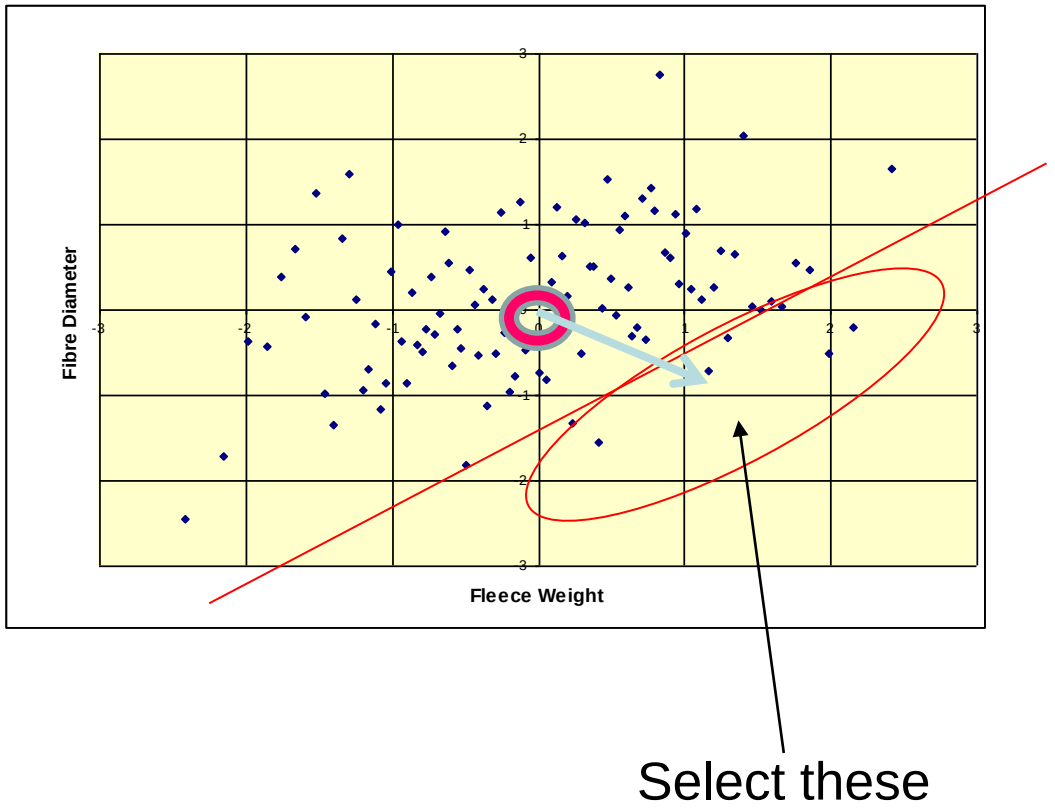
- Post Weaning Weight and Eye Muscle Depth are positively correlated
- Advantageous for common breeding objective (of increased PWWT and EMD)



Multiple trait selection: can we go anywhere we want?

Some correlations are unfavourable

- Fleece Weight and Fibre Diameter are positively correlated
- Disadvantageous for breeding objective (of increased FW and decreased FD)
- Could they both be improved?



Yes – as genetic correlation is not one, but genetic change per trait will be slower

Range of possible responses

r_A=1 or -1

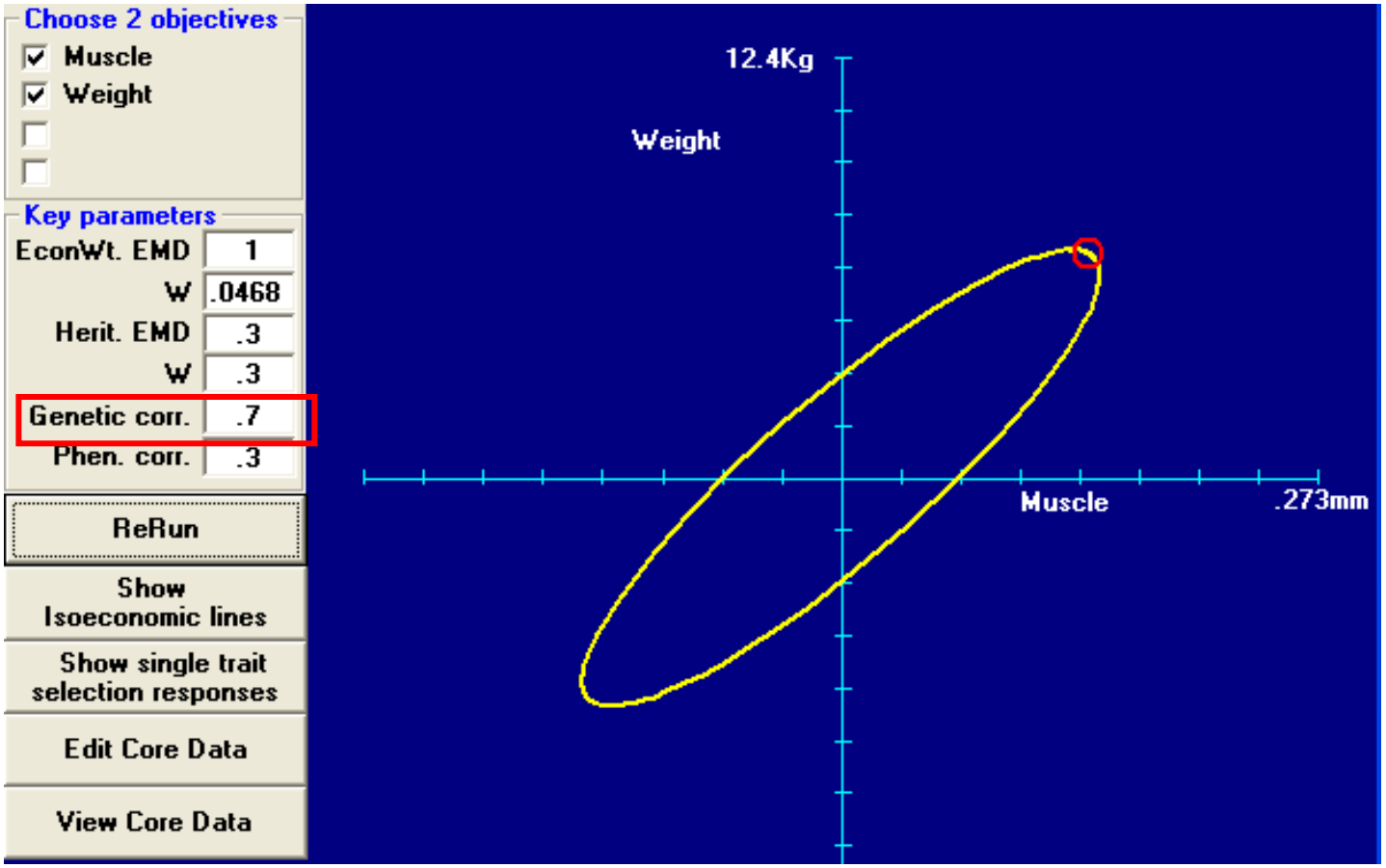
- r_A=1 both traits will always change in same direction
- r_A=-1 both traits will always change in the opposite direction

r_A between 0 and 1

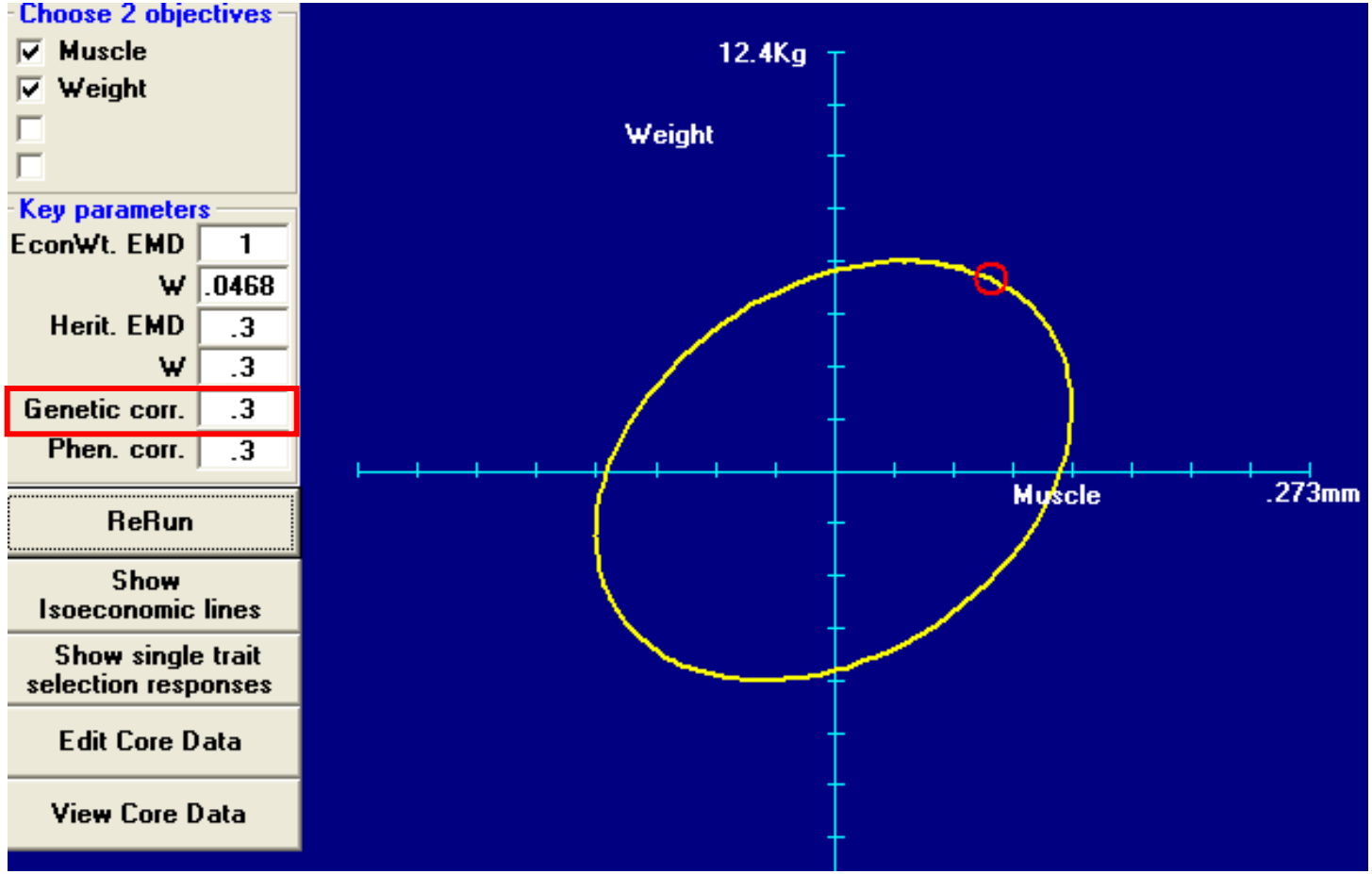
- easy to change traits in same direction
- possible to change traits in opposite direction
  - harder if r_A is closer to 1
  - Compromise: maximal response is not obtained for either trait

r_A between 0 and -1

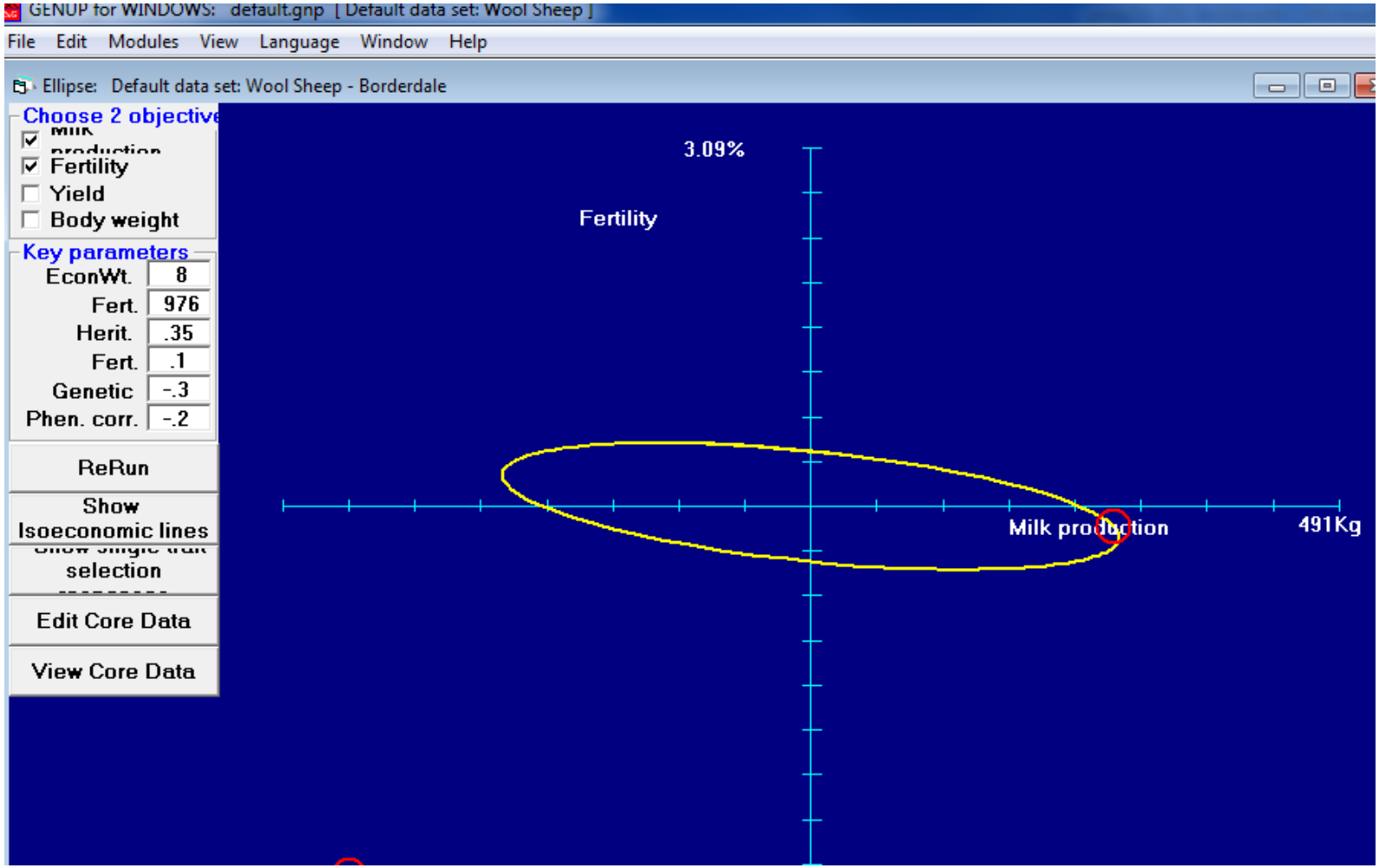
- easy to change traits in opposite direction
- possible to change traits in same direction
  - harder if r_A is closer to -1
  - Compromise: maximal response is not obtained for either trait



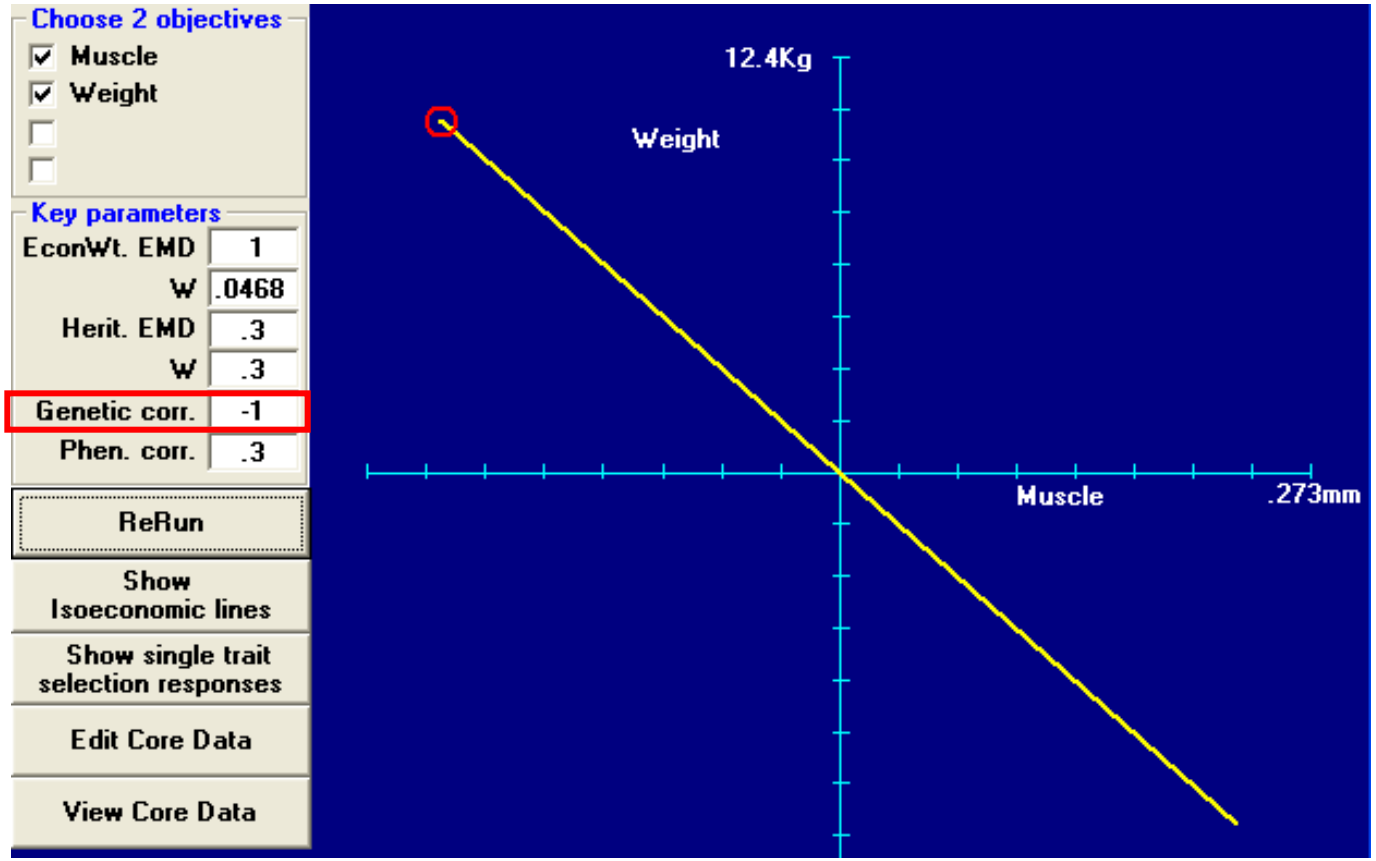
- The ‘ellipse’ is the range of possible outcomes, in one generation
- As association is positive
  - most possible outcomes lie in quadrants for high PWWT and high EMD, or low PWWT and low EMD
  - some possible outcomes lie in the other quadrants



- As association is positive but less strong
  - Progress for PWWT does not automatically imply progress for EMD
  - some possible outcomes lie in the other quadrants

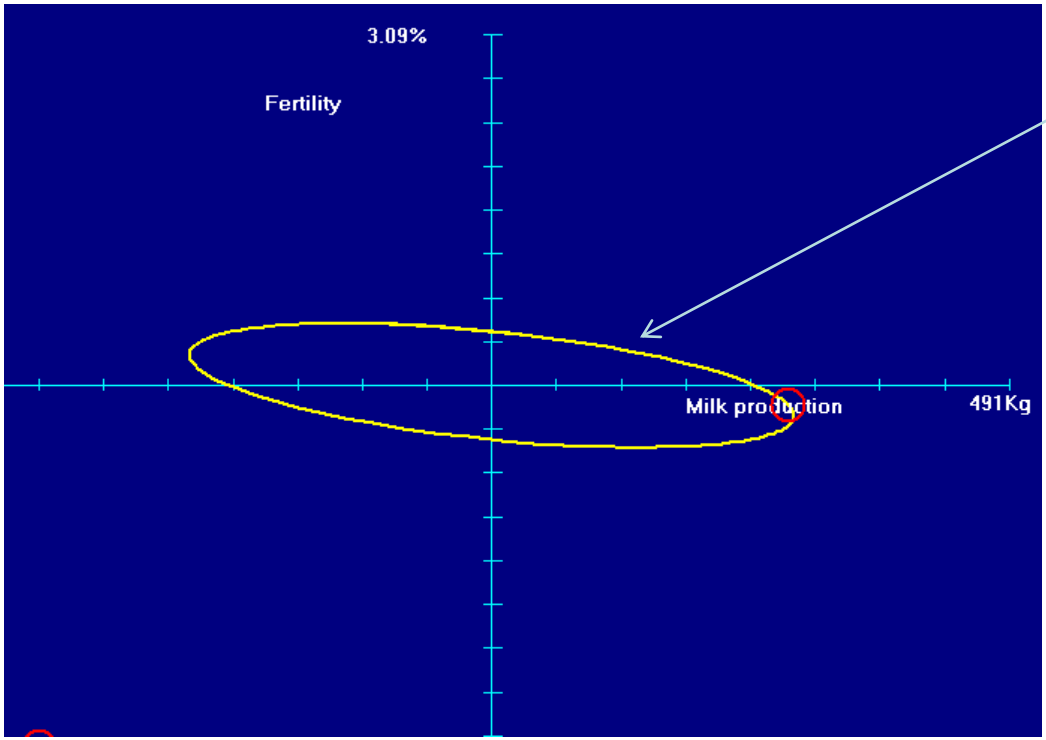


- If correlation is negative
  - More difficult but not impossible to increase both traits,
  - Example: Milk Production and Fertility In Dairy Cattle



- If genetic correlation is -1
  - Could not increase both traits
  - Rarely happens

Varying trait response



How can the different relative responses be achieved?

Can we try to increase Fertility?

Place different weights on the information sources

→select on an index

Index = b_{Milk}.Milk + b_{Fert} * Fertility

weights

Multi trait indexes

- EBVs calculated via multi-trait BLUP already account for relationship between the traits

- To combine individual trait EBVs into an index, simply weight by the economic value

$$\$index = ev_{trait1} \times EBV_{trait1} + ev_{trait2} \times EBV_{trait2} \cdots$$

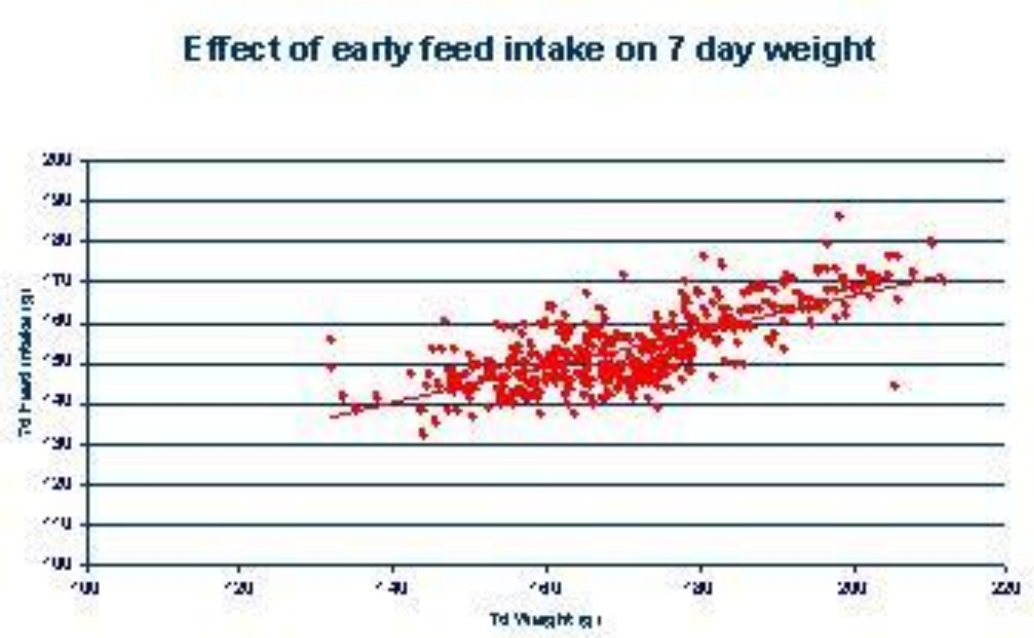
How can we manipulate response?

Change relative economic values of the two traits

Change index weights of the two traits

Change relative response of the two traits

Case study



http://www.aviagen.com/

Case study

Weight (W) & Feed Intake (FI)

- Positive genetic correlation

Look at responses for different

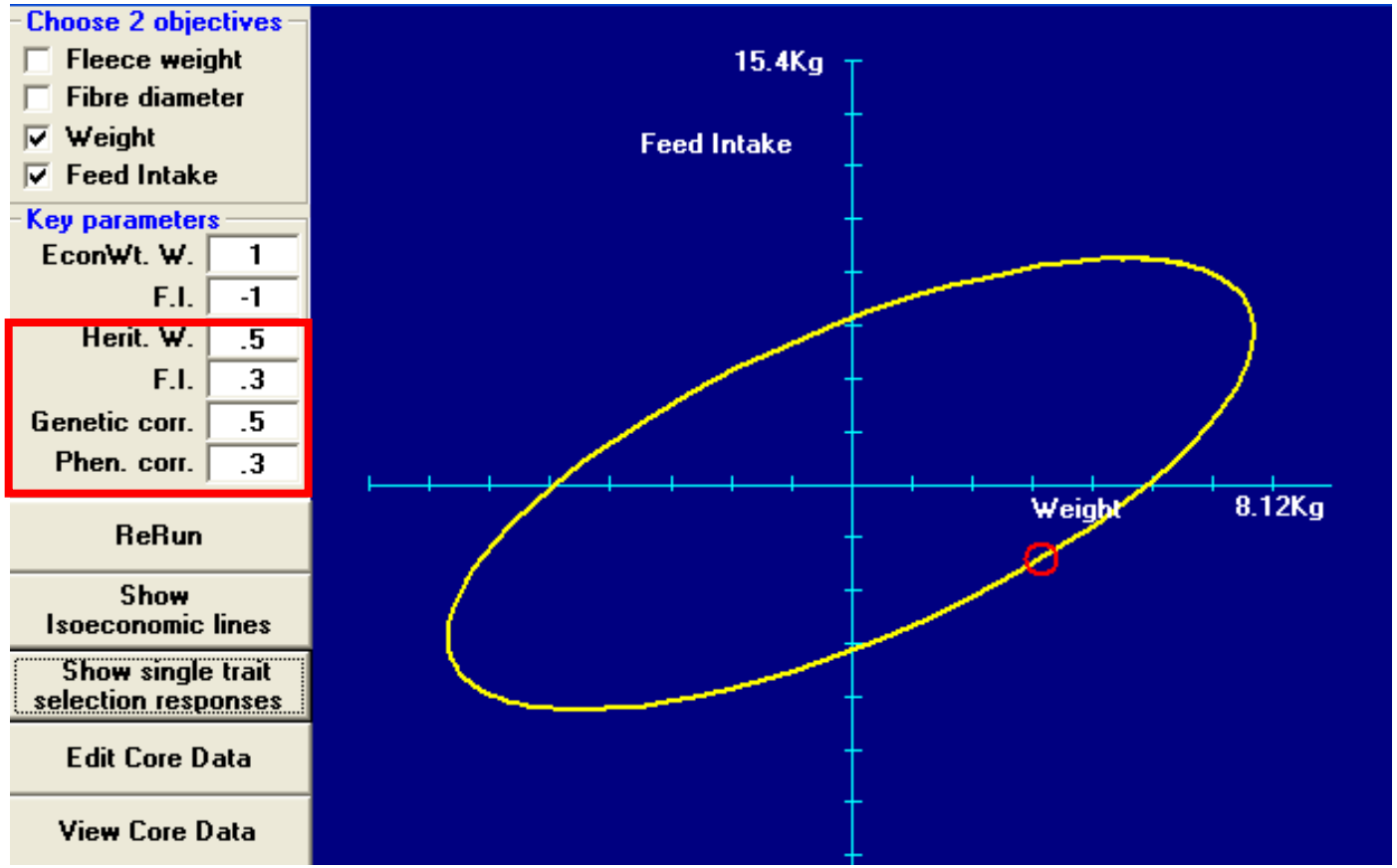
- Breeding objectives
- Selection criteria
- Economic weights

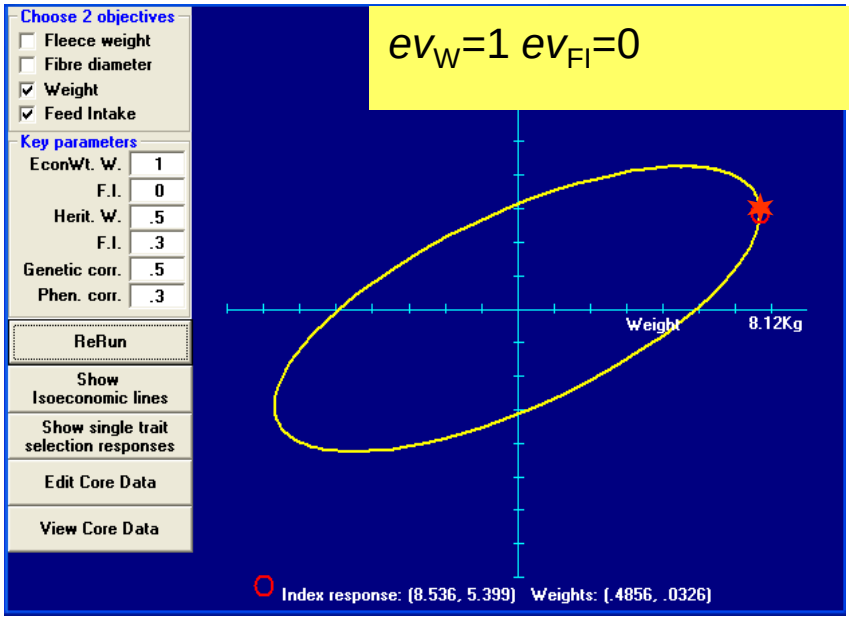
parameters

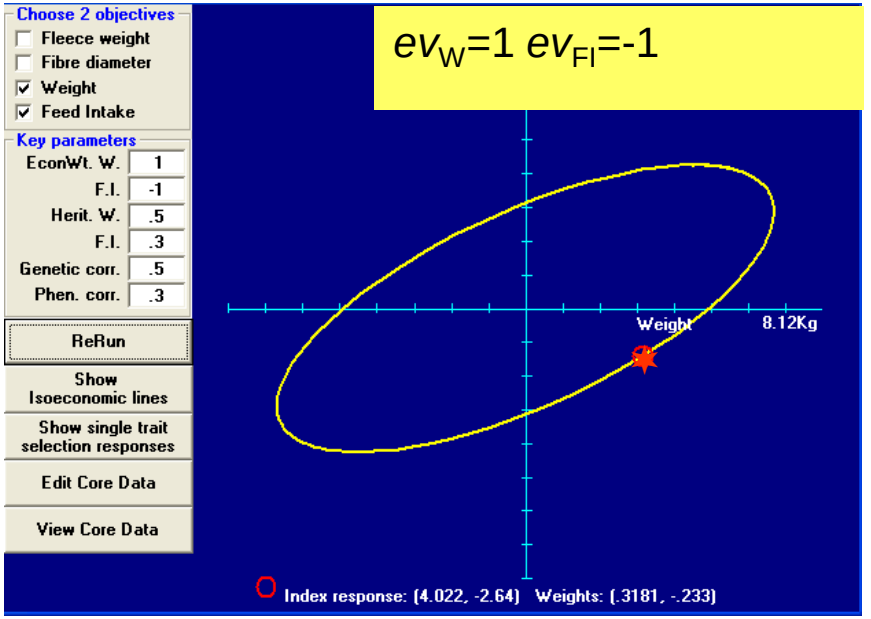
	h^2	σ_P
W	0.5	17kg
FI	0.3	25kg
r_A	0.5	
r_P	0.3	

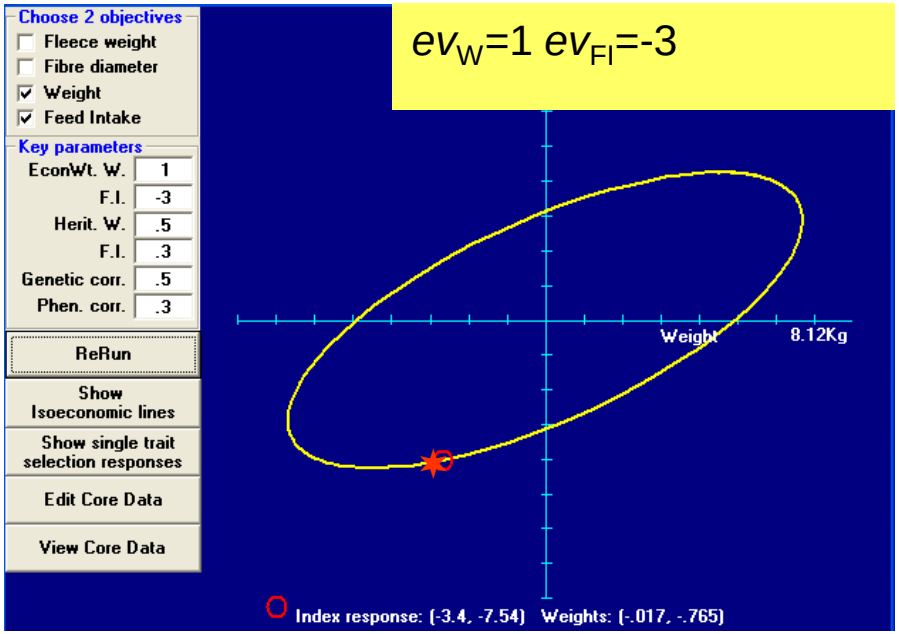
Some big chooks!

Ellipse of possible responses









✶ = point of optimal response when selecting on an index

Points to note

- Changing the economic value of traits, alters the index weights, and thus response
- The highest $ return is achieved when the index weights are calculated using the true economic values
- Definition of an economic value – is $ return for a one unit trait increase (all other traits held constant)

Could we decrease feed intake with no change in weight?

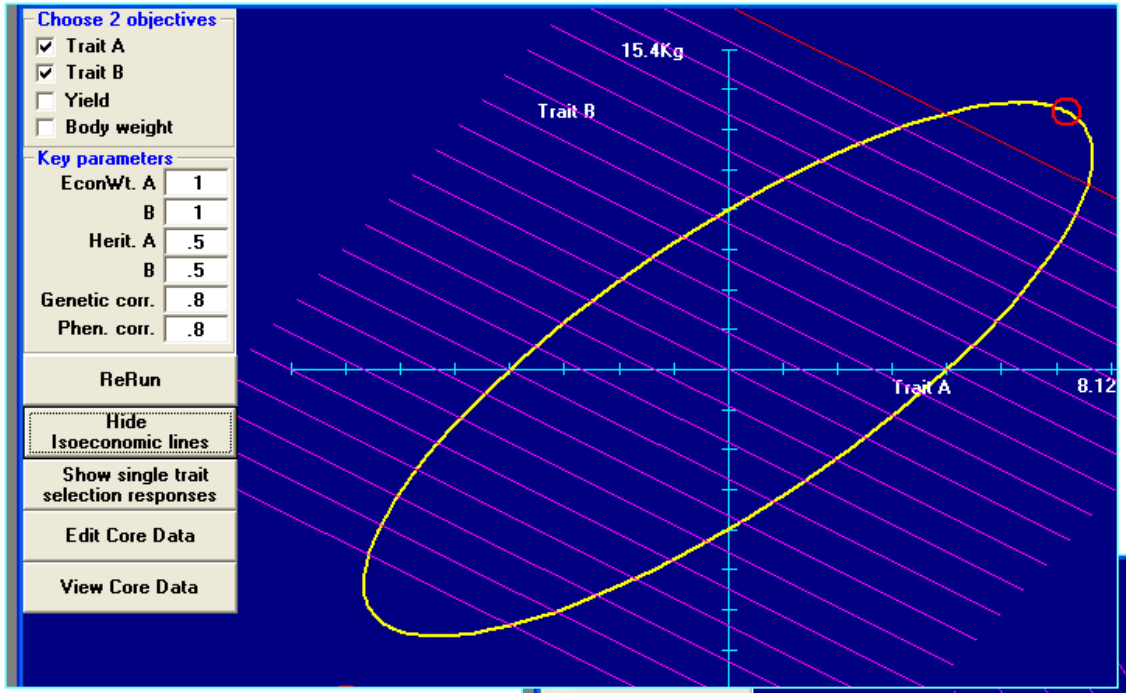
Could we increase weight with no change in feed intake ?

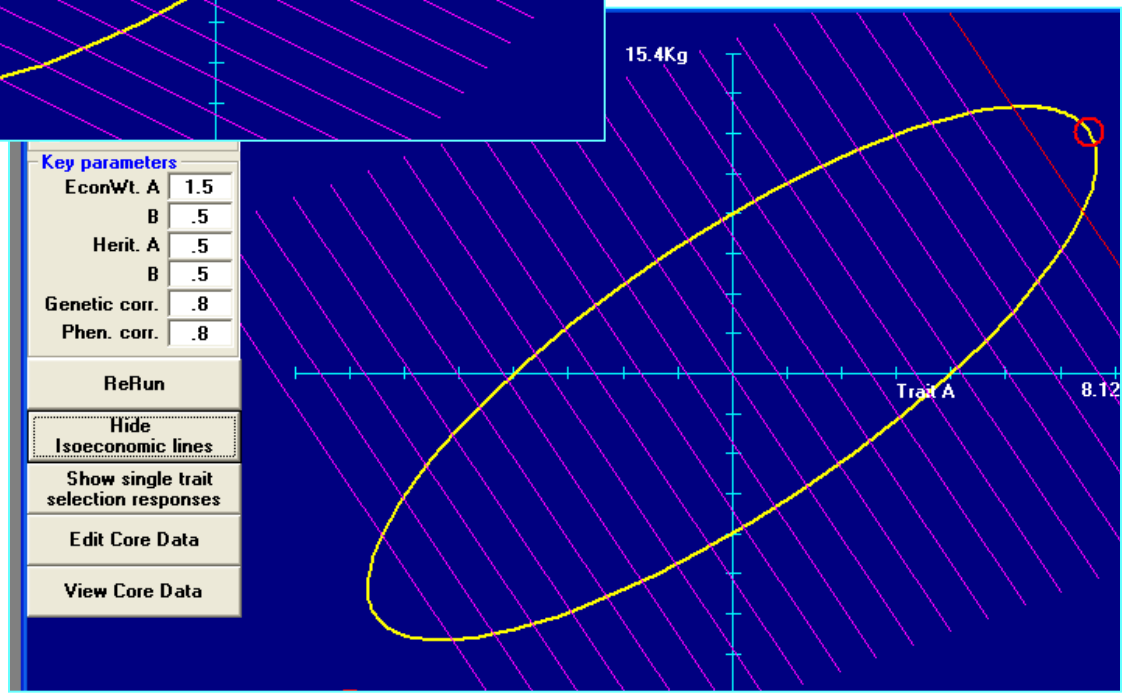
Could we increase FW and decrease FD in merinos?

Could we increase FW, NLW, PWWT, EMD, SS and decrease FD, WEC, AdultWT in merinos?

A challenge

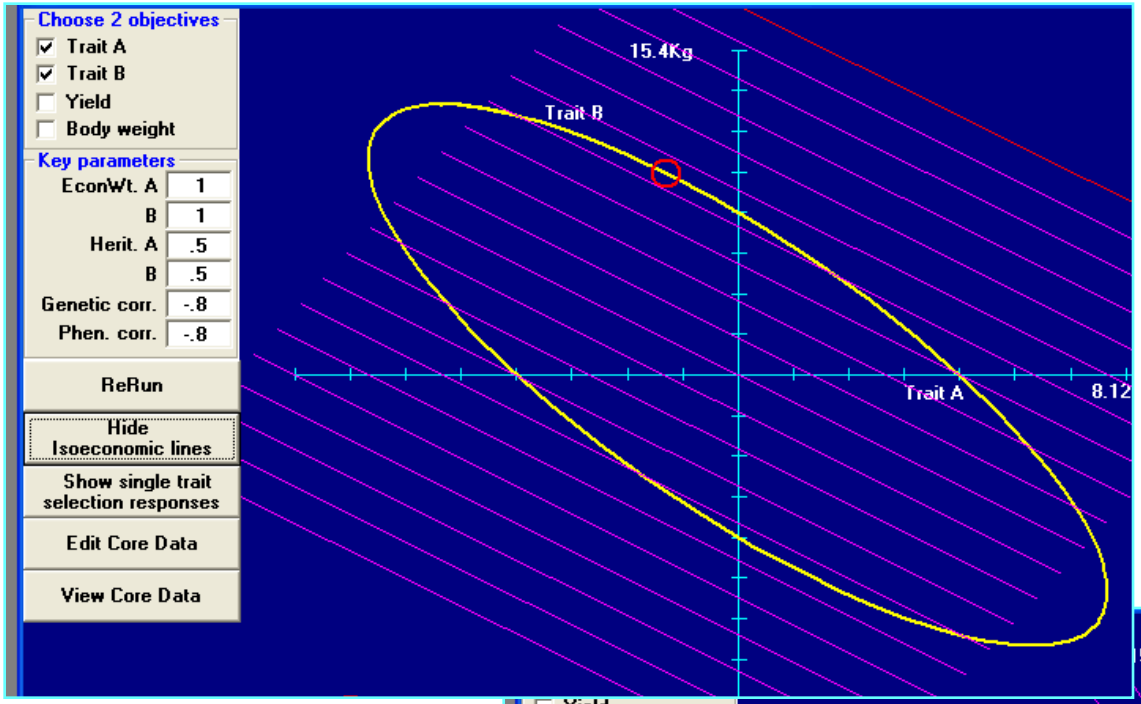
- Assume two traits have a positive economic values
- Why is selection for these traits less sensitive to economic values when they are positively correlated compared to when they are negatively correlated

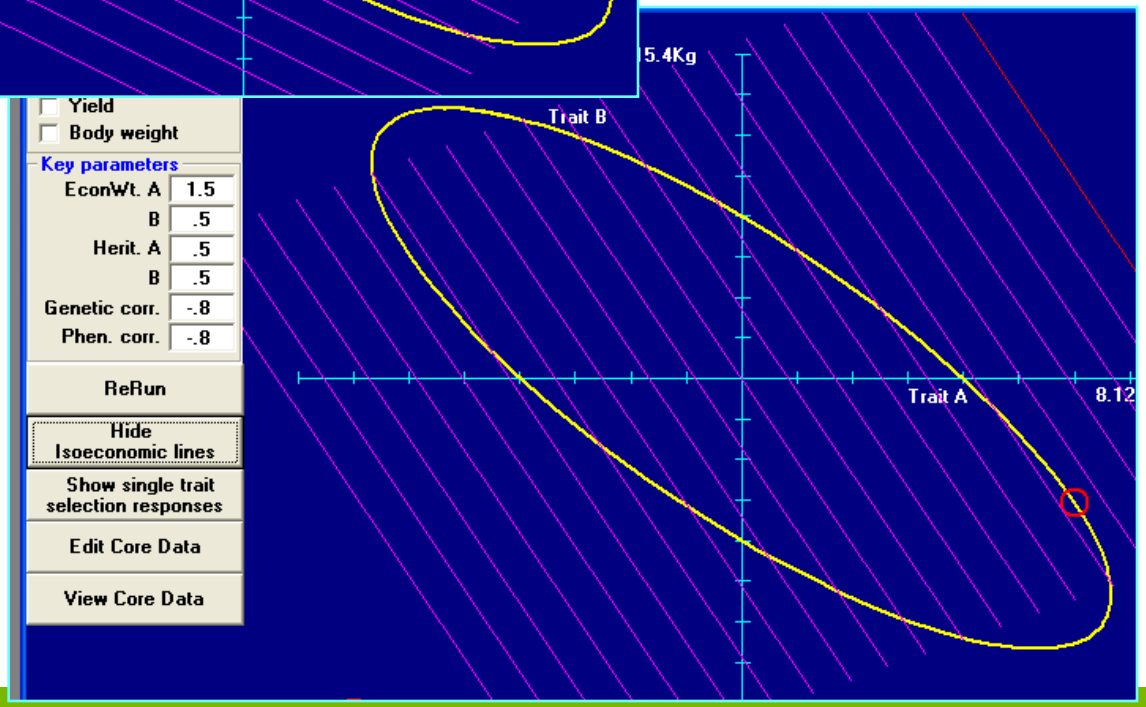




Not sensitive

Favourable correlation





Sensitive

Unfavourable correlation

Breeding Objectives

- traits affecting profit
- economic values of traits

$$\text{Objective} = a_1 BV_1 + a_2 BV_{2+} \ldots + a_m BV_m$$

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- traits affecting profit
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$$\text{Objective} = a_1 BV_1 + a_2 BV_{2+} \ldots + a_m BV_m$$

How do we derive economic values?

Definition:

- Economic value of a trait is the change in profit after changing the mean for that trait by one unit

- Use profit functions

Profit per ewe = FleeceWght * price/kg – cost per ewe

= 4 * 10 – 10 = $ 30

Now increase FW by one unit:

= 5 * 10 – 10 = $ 40

Hence the economic value of 1 kg increase in FW is $10

More challenging to account for change in Fibre Diameter!

Spreadsheets are good tools to work this out!

LECTURE 14 GENE422/522		Income per ewe after 1 unit increase	Economic Value
Trait	Mean		
Weaning Rate	1.2	33.5	15
Days to Slaughter	100	18.2	-0.3
Fleece Weight	3.5	21.5	3

Constants	
Sale Weight	40
Weaning Weight	20

Prices	
Lamb Value per kg	$1.00
Lamb Cost per day	$0.25
Fleece Value per Kg	$3.00
Annual Cost per ewe	$10.00

Calculation of Net income	
Income per ewe	$0.50
Income per lamb	$15.00
Net income per ewe	$18.50

Economic values do not guarantee a ‘’desired’ response for a single trait !

	Economic Weights
Weight	1 $/g
Feed Intake	-0.5 $/g

R_W = **6.93** kg

Index = 1. EBV_W - 0.5EBV_{FI}

R_{FI} = **0.39** kg

Negative economic weight

Yet, a positive response

Changing economic values can give a ‘’desired’ response for single traits!

Weight	1 $/g
Feed Intake	-10 $/g

Economic Weights

Desired gains: change economic value until desired outcome

good idea?

Index = 1. EBV_W – 10 EBV_{FI}

A larger weight……

R_W = **4.29** kg

R_{FI} = **-0.05** kg

..gives a negative response

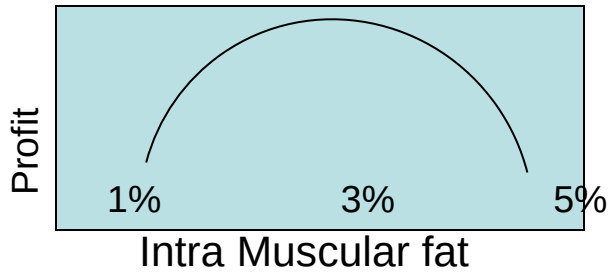
Selection index with 'desired gains'

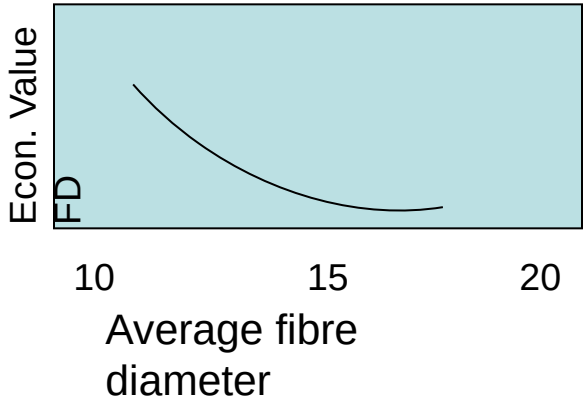
- Rather than
  - determine econ. values >>>> response
  - We desire a response >>>> economic values (implicit)

When useful?

Breeding objectives are subject to debate!

- Are selection indices always linear?
  - nonlinear profit function
  - optimal traits
  - threshold values for profit

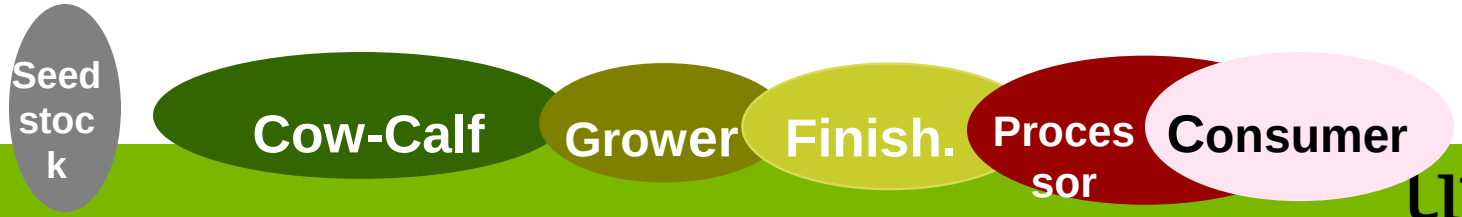




- Are the same indices (= econ. wghts) valid for all?
  - - what could be reasons for differences?

Breeding objectives are subject to debate!

- Who's perspective for profit?
  - Breeder: selling bulls Producer: buying bulls
  - Maximize profit per head….more lambs/ewe is good
    …….or per ha….. more lambs/ewe only good if lambs are more profitable than ewes
  - Profit of who? producer; whole sector; consumer



Example reference point

(going for bigger is not necessarily better)

Breed	Value of weight at slaughter	Value of food consumed	Profit per head	Dollar efficiency
Small	$200	$100	$100	2:1
Large	$350	$200	$150	1.75:1

Summary

Need to set breeding objectives by

- defining the traits
- and their economic value

Economic value is change in profit if individuals perform one unit more for that characteristic

Indexes are used for multiple trait selection

Sometimes the optimal response is sensitive to economic values (esp with unfavourable correlations)