Breeding cattle to produce less methane per kg product: how?

#phenotypeisking

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Menu

1kg = 2.2 pounds

- What we have been doing in dairy
- What we have been doing in beef
- Convergence of beef and dairy
- Where to next?
- The future is not what it used to be
  - Age at first calving
  - Age at slaughter
  - Cow size
  - Calf survival
  - Reacting to environmental signals

- Reducing methane per kg product
- Now
- Speed

We have already been doing it!

- Increased production per cow
- Improved disease resistance
- Increased fertility

- Dilute fixed maintenance costs
  - Fewer cows to produce same product
- Reduced wastage of productive days
- Reduced wastage of infertile cows and fewer replacements
- More opportunities to select best cows
  - Sexed semen has helped
  - More beef from dairy herd

- Lower environmental cost

Modern dairy breeding goals are (relatively) good for the environment as well as the cow and the farmer.

What will it look like in the future?

- Win/win/win situation

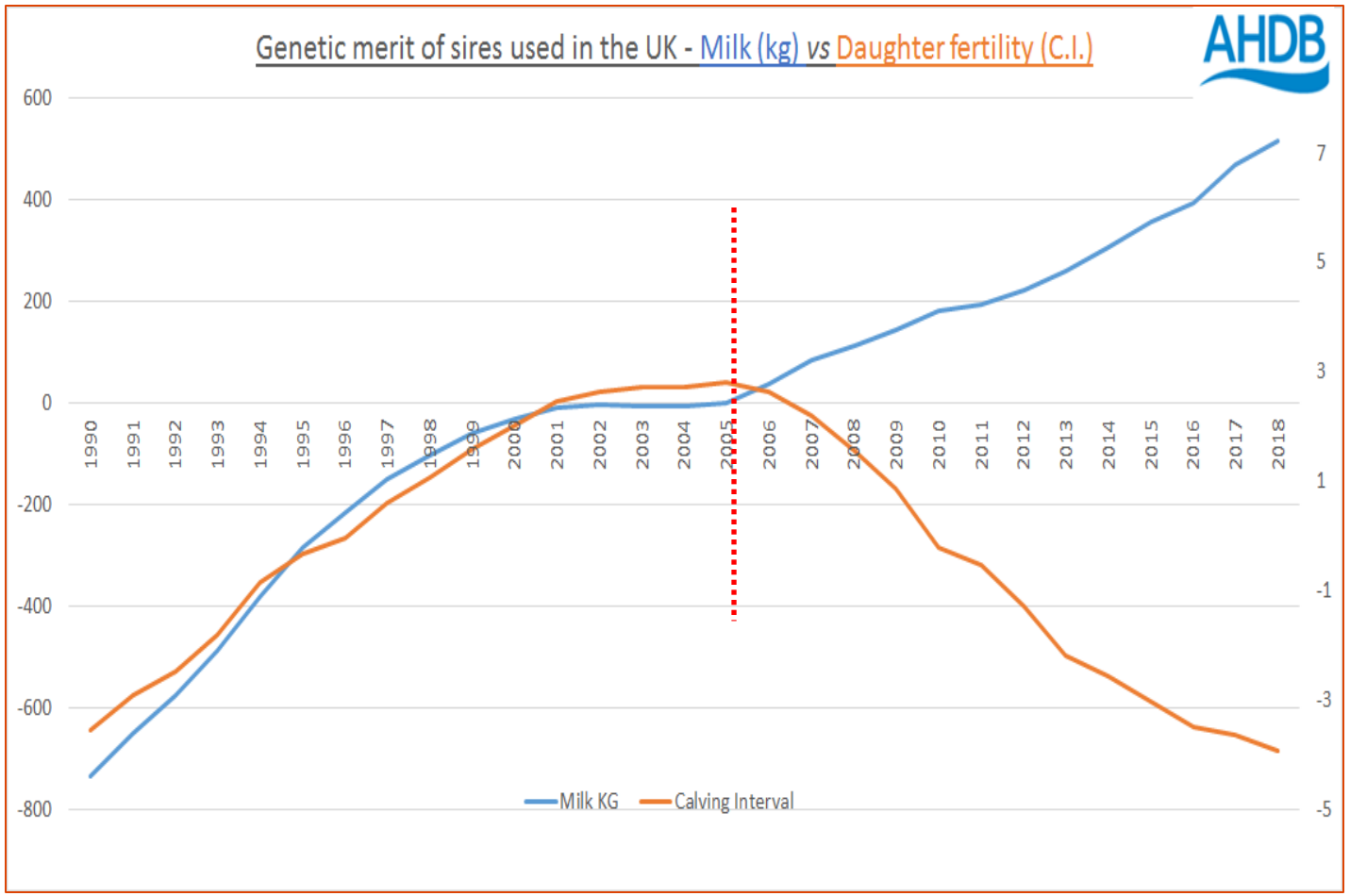
- Changed production environment
  - Previous practices now unacceptable e.g.
    - Using antibiotics on all dry cows
    - Exporting live calves
    - Euthanising calves routinely on-farm
    - Pulling hedge rows to make bigger fields
    - Applying excess fertiliser
    - Feeding excess concentrates
    - Etc.

- We need to ensure cattle breeding meets society's needs as well as farmers

Imperative

- Climate change
  - Extreme weather events
- Recent geopolitical events
  - Price shocks
  - Raw materials availability
- Fragile supply chains

- Energy will continue to be expensive
- Resource use efficiency is key
- Focus on feed efficiency and environmental cost NOW


Genetic merit of sires used in the UK - Milk (kg) vs Daughter fertility (C.I.)
AHDB
600
400
200
0
-200
-400
-600
-800
7
5
3
1
-1
-3
-5
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
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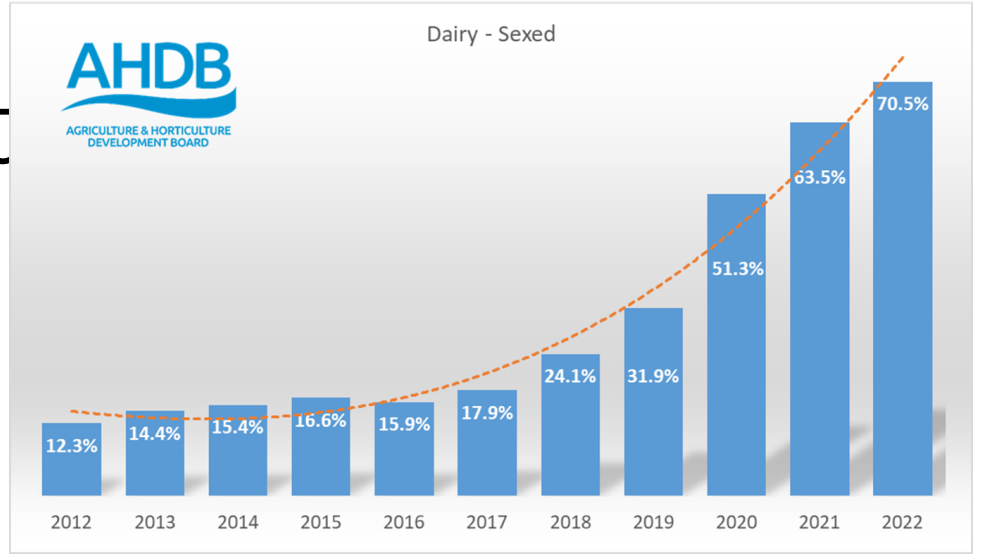
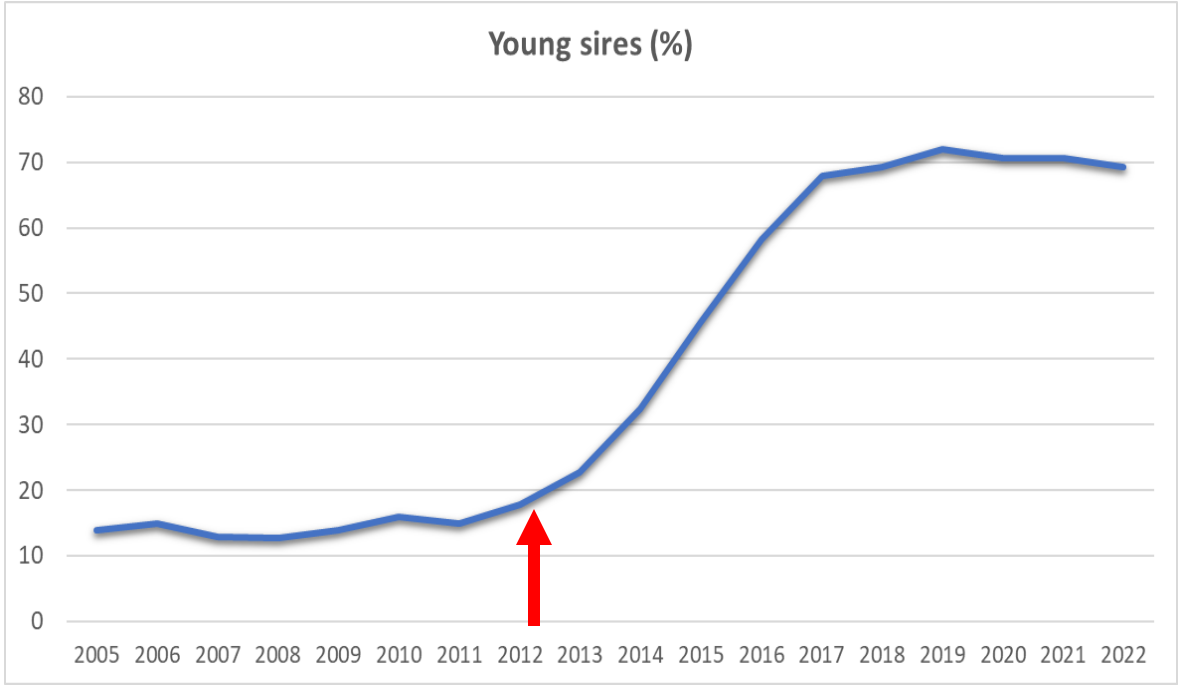
2010
2011
2012
2013
2014
2015
2016
2017
2018
Milk KG
Calving Interval

UK dairy breeding in a snapshot

- Use of sexed dairy ⬆
  - ✓now >70% of all dairy inseminations
- Use of beef semen ⬆
  - ✓Close to 50% of all inseminations
- Use of genomic young sires ⟷
  - ✓at ~70% of all dairy inseminations
    - ➢ (doubling genetic progress !)





BUT

- Things are not optimal
- Cows are getting bigger
- We need to reverse that trend

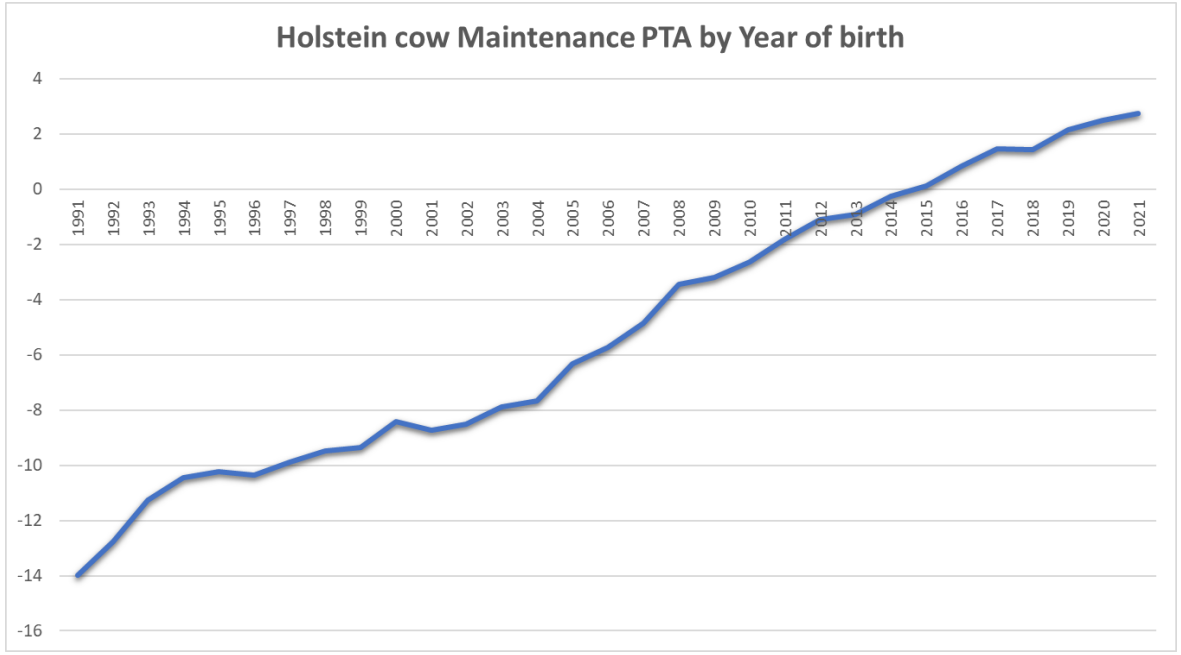
- Do more of what we have already done and doing it faster can reduce methane emissions NOW

- AND recording methane emissions is required for longer term selection

- The most important word is AND
- The second most important is NOW

Breeding has significantly changed today's cow

Unfavourable trend in Maintenance



- Bigger cows means we now have an equivalent of 60,000 tonnes of cow LW to feed each day in the UK !
  - Which is ~90,000 mature HOL cows
- For an average herd of 200 cows
  - Roughly 10 extra cows to feed
    …each day
- Will take some years to reverse because bulls are already in the system

Nobody weighs cows

- We have over 10m abattoir records
- We have all British Cattle Movements data
- We have all milk recording data
- We have many breed society databases

- We have ‘no’ national cow weight data

- So we predict it from cull cow carcass weights
- Cant yet predict killing out percentage

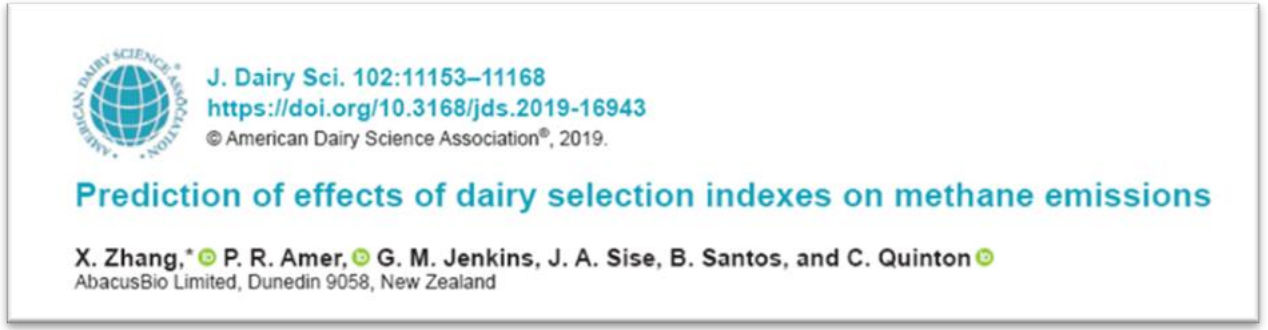
EnviroCow

- Genetic index to reduce CO_2 equivalent per kg product produced
  - Using Methane production as our target GHG

- Many of our indexes already contribute to improved efficiencies (!)
  - E.g. Yield per cow, improve health, improve lifespan, reduce feed

- We calculate Methane Intensity = Gross Emission per KG product (Kg Protein equivalent)
  - For every trait we can calculate additional contribution to both Emission and Product (‘*Trait Intensity*’)

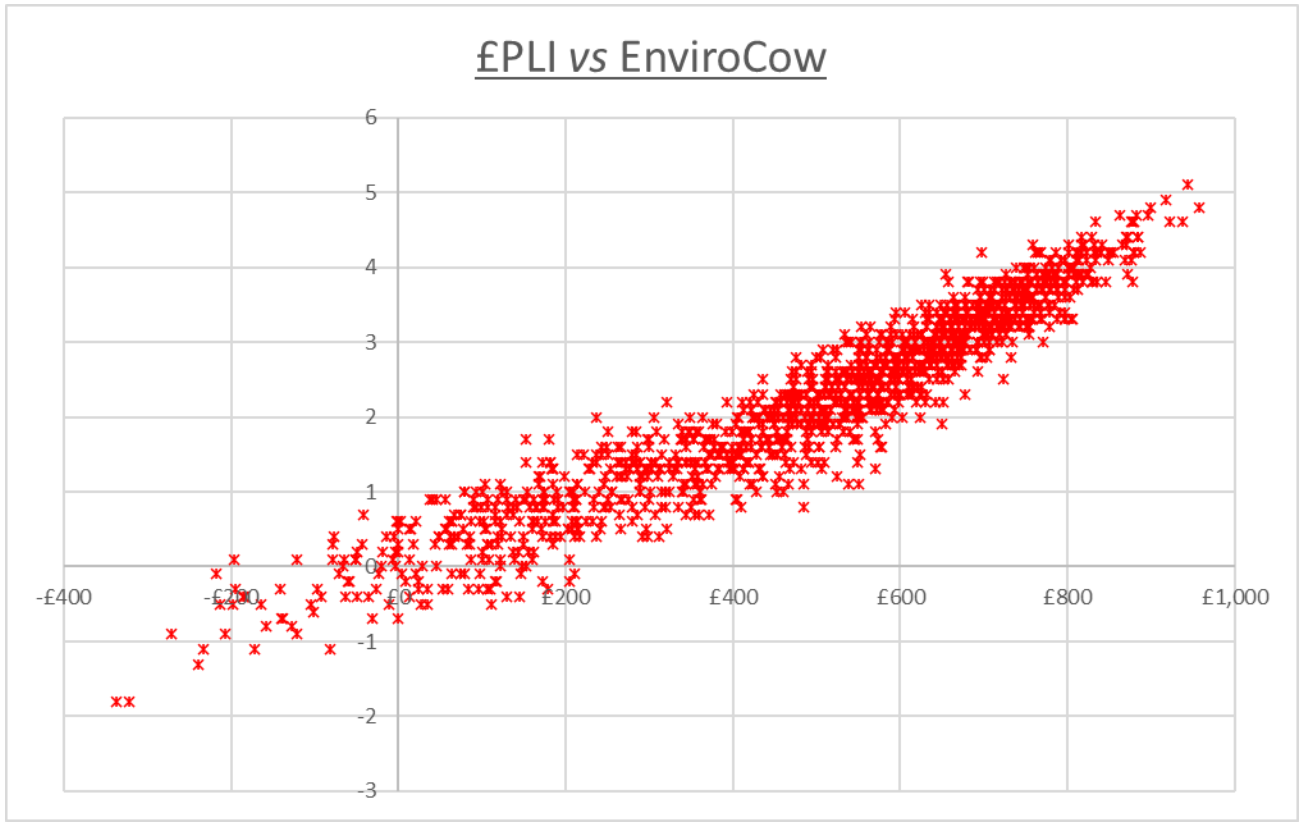
- Using the Mature cows output as;
  - Milk, Fat, Protein (per lactation)
  - Meat (cull cow – once in her lifetime)


J. Dairy Sci. 102:11153–11168
https://doi.org/10.3168/jds.2019-16943

Prediction of effects of dairy selection indexes on methane emissions

X. Zhang,* P. R. Amer, G. M. Jenkins, J. A. Sise, B. Santos, and C. Quinton
AbacusBio Limited, Dunedin 9058, New Zealand

Active Holstein bulls



EnviroCow	Count
6	1
5	60
4	343
3	403
2	305
1	211
0	67
-1	6
-2	0
-3	0
-4	0
-5	0

Beef production in UK

Suckler herd (cow calf)

Dairy herd

Many suckler cows are part bred Holsteins

- We have a range of beef indices
- Rely on beef farmers recording
- Beef recording is fragmented
- Utilise carcass traits from abattoir data
  - > 10m carcass traits records from most UK abattoirs
  - Pedigree from BCMS

National Beef Evaluations

AHDB

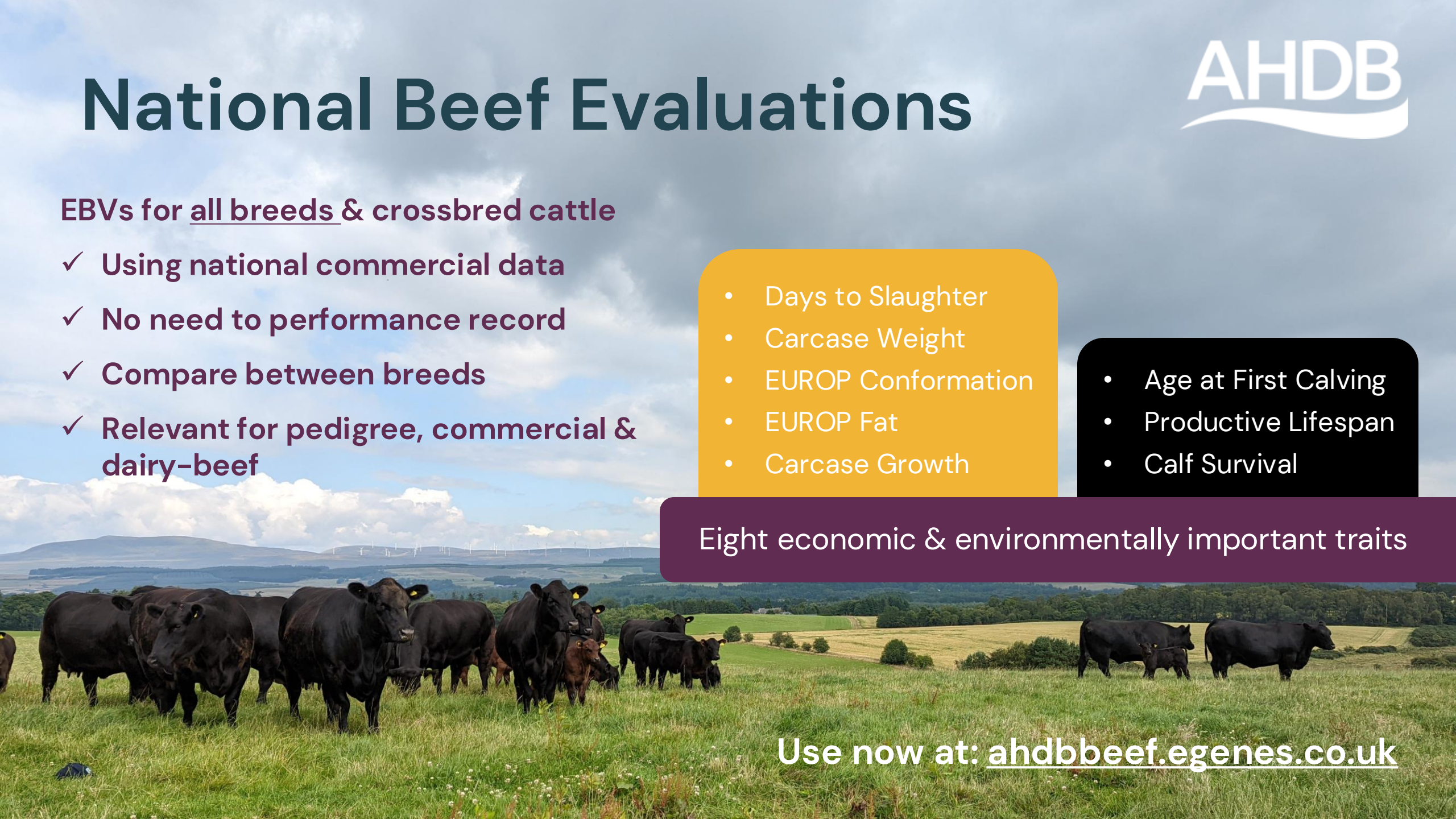
EBVs for all breeds & crossbred cattle

- ✓ Using national commercial data
- ✓ No need to performance record
- ✓ Compare between breeds
- ✓ Relevant for pedigree, commercial & dairy-beef

- Days to Slaughter
- Carcase Weight
- EUROP Conformation
- EUROP Fat
- Carcase Growth

- Age at First Calving
- Productive Lifespan
- Calf Survival

Eight economic & environmentally important traits



Use now at: ahdbbeef.egenes.co.uk

Suckler beef production

(cow calf)

- Simplistic view at population level

- Calf is born, survives and calves at 2 years of age at 650kg
- Cow matures at 750kg at 4 years old
- Cow has 4 annual calves in lifetime
- Calf produced becomes 700 kg prime beef animal

Suckler cow production cycle

2 years
730 days

650kg Heifer

700kg Cow

750kg Cow

750kg Cow

Lifetime total
1,058,500 kg/days

40kg Calf

700kg prime beef

700kg prime beef

700kg prime beef

700kg prime beef

Lifetime total
2800kg prime beef

Lifetime total
0.00265kg prime beef Per kg / day (+ 750kg)

Suckler cow production cycle

40kg Calf

2 years
730 days
650kg Heifer

700kg Cow

750kg Cow

750kg Cow

Lifetime total
1,058,500 kg/days

0kg prime beef

700kg prime beef

700kg prime beef

700kg prime beef

Lifetime total
2100kg prime beef

-25%

Lifetime total
0.00198 kg prime beef Per kg / day

Suckler cow production cycle

3 years
1095 days

+237,350 kg/days (+65.4kg CH4)

650kg Heifer

700kg Cow

750kg Cow

750kg Cow

Lifetime total
1,295,750 kg/days

40kg Calf

700kg prime beef

700kg prime beef

700kg prime beef

700kg prime beef

Lifetime total
2100kg prime beef

-18%

Lifetime total
0.00162 kg prime beef Per kg / day

#bigcowsarebad

That includes suckler cows

So what can we do about it?

What data do we have to investigate it?

What data would be good to collect?

- Increased maintenance costs (ongoing)
- Increased growing costs
- Increased lameness odds
- Increased DA odds

- Higher cull cow value
- Higher beef calf value

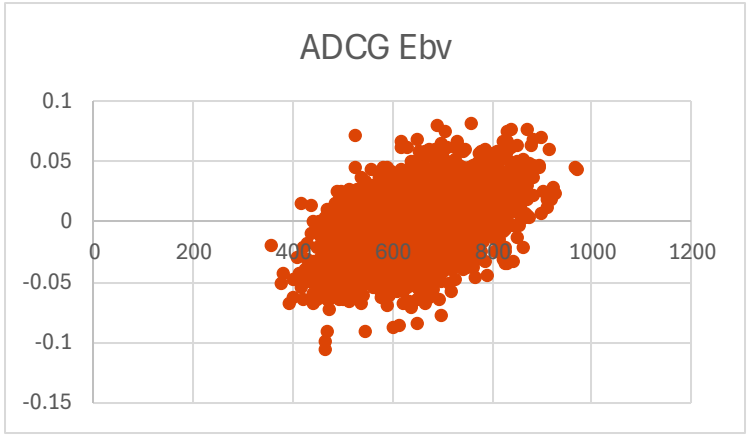
- Higher environmental cost

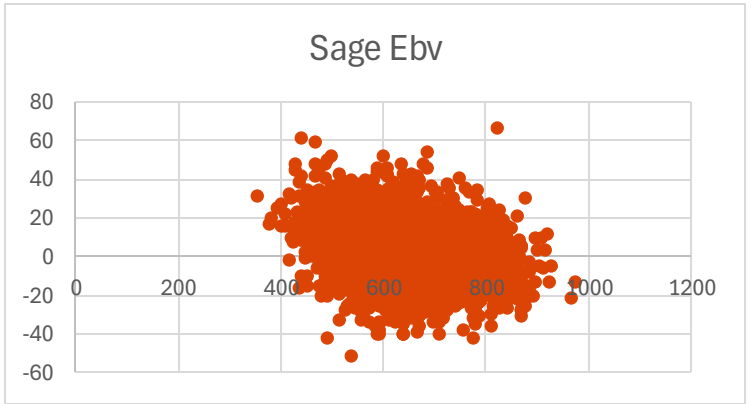
Cull Cow carcass weight as a proxy for liveweight
Top and bottom 10 sires average of dtrs cull weight (55% KO)

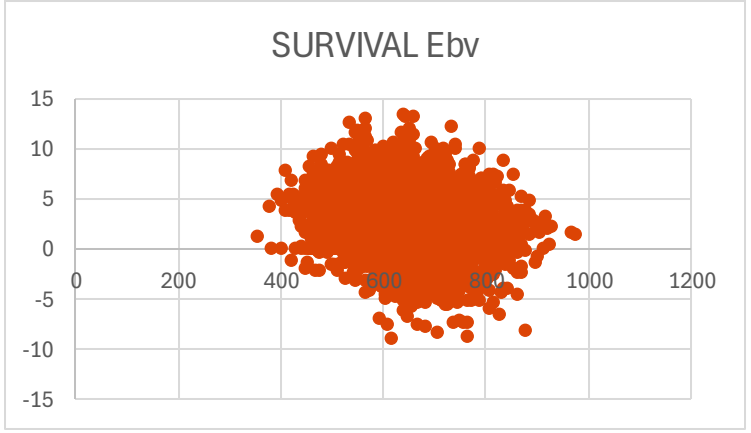
LWT	recs	codedSireId	breedgroupdesc
971.8	10	32475432	Charolais
969	11	153055197	Charolais
964.8	14	153055212	Charolais
944.7	10	41989324	Charolais
936.6	15	33027389	British Blue
932.5	18	152989688	Charolais
927.9	13	24749826	Charolais
926.7	12	24743081	Blonde D'Aquitaine
919.4	11	16930835	British Blue
915.7	10	24553592	Blonde D'Aquitaine

.....

LWT	recs	codedSireId	breedgroupdesc
417.7	12	2889682	Aberdeen Angus
415.8	12	30896228	Beef Shorthorn
410.3	16	36737831	Beef Shorthorn
406.8	19	1145916	Beef Shorthorn
398.9	11	24994436	Red Poll
398.9	16	11935262	Beef Shorthorn
391.8	11	3823891	Aberdeen Angus
380.7	11	43360490	Galloway
376	10	10466562	Galloway
354.6	18	14497137	Beef Shorthorn







SRUC

What's the cost?

Smaller cows

2 years
730 days
550kg Heifer

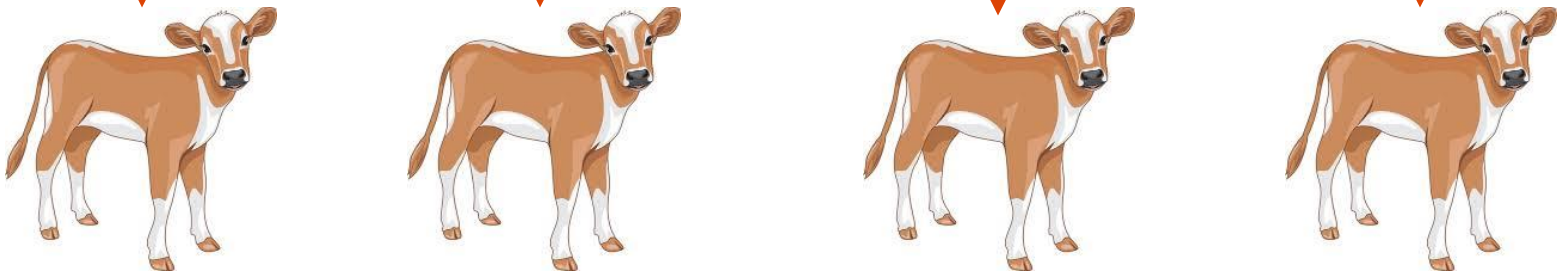
600kg Cow

650kg Cow

650kg Cow

Lifetime total
876,500 kg/days

40kg Calf



700kg prime beef

700kg prime beef

700kg prime beef

700kg prime beef

Lifetime total
2800kg prime beef

+17%

Lifetime total
0.00319kg prime beef Per kg / day

Cull Cow carcass weight as a proxy for liveweight
Top and bottom 10 sires ranked on average of dtrs cull weight (47% KO)

localsireid	avg_wt	recs
65000001388867721 1M	760.4	135
6500000070726929 11M	750.8	133
6400000011278908 11M	749.1	122
6000000536743019 11M	733.3	107
6300000755898972 11M	729.9	171
6500000132825342 11M	722.2	193
6400000108048659 11M	722.2	148
650000012227479811M	721.6	100
0100000000662653 11M	719.9	354
6500000069990138 11M	716.2	235
650000006998134911M	715.8	154
.....		
.....		
200000000060314911M	571	158
620000000009839011M	571	133
200000000058389411M	570.5	147
620000000009632911M	569.1	420
200000000063869511M	566.2	131
620000000010813811M	565.6	113
620000000010608311M	557.3	143
620000000010607911M	539	132
620000000010823511M	538.9	116
84377913	535.9	101
620000000010823711M	530.1	174

Development of UK (Smart) dairy indices

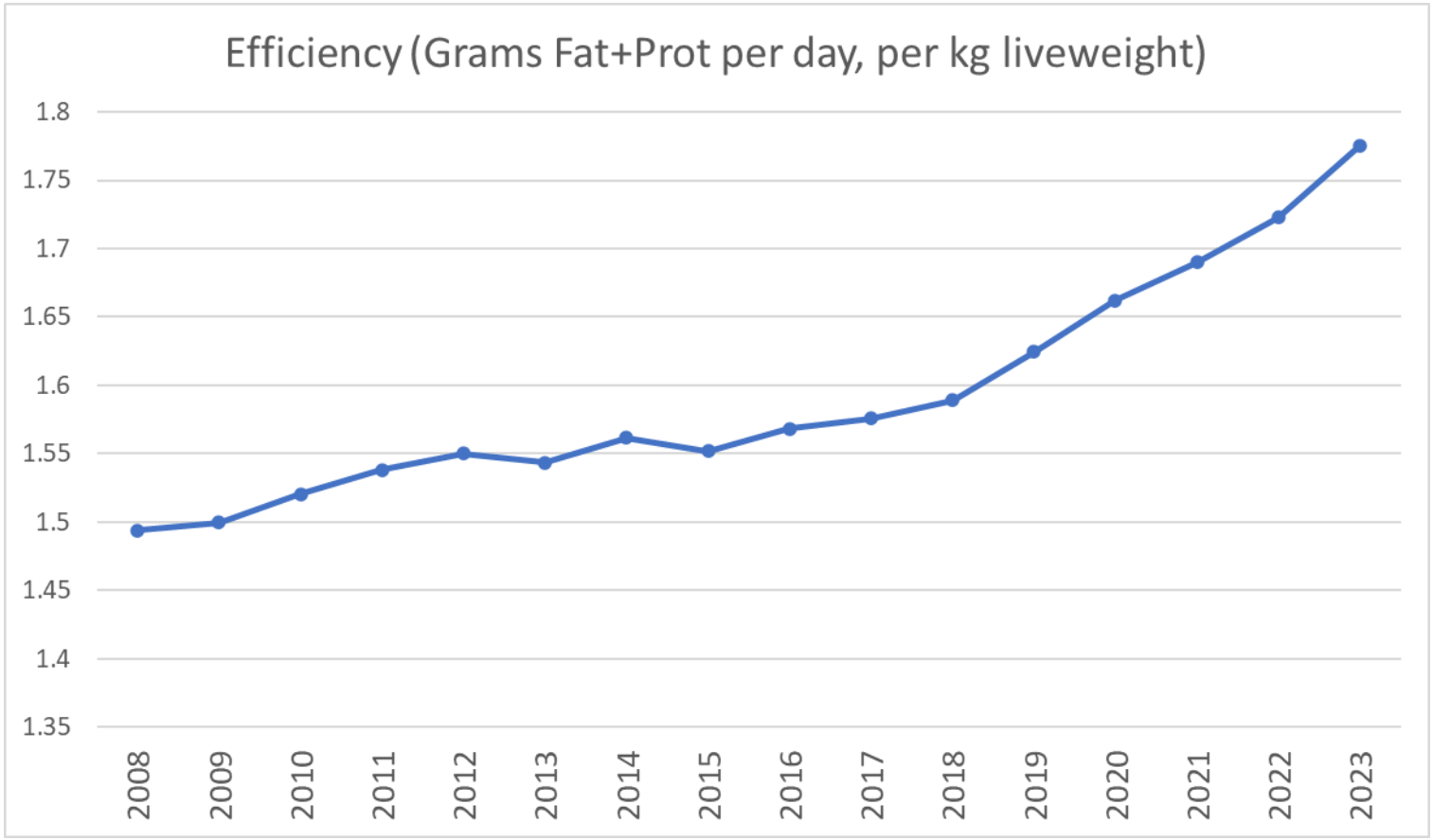
£PLI (cows
- Fertility
- Mainter
- Actual f
-Feed int
predicted
- Stillbirth
- Johnes

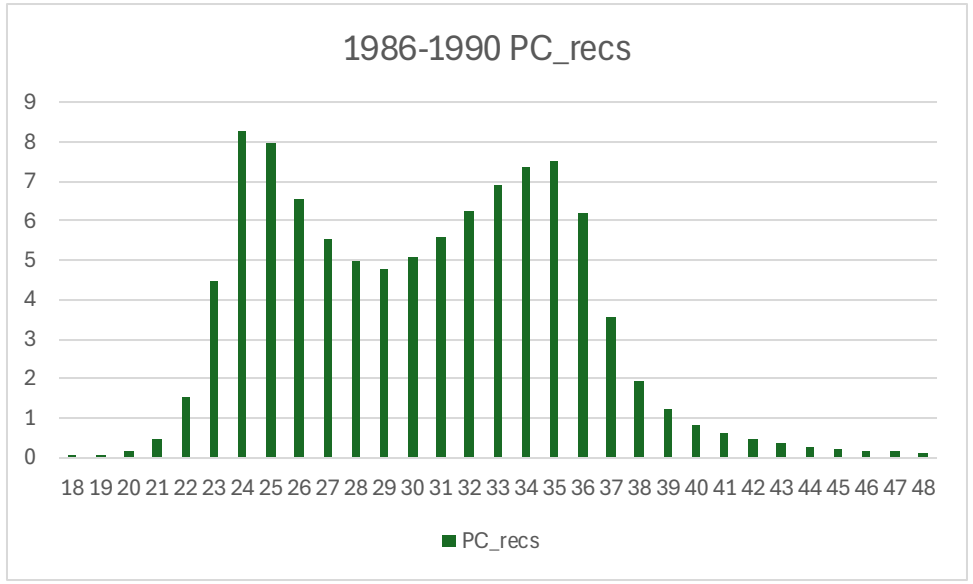
£PLI (cows & bulls)
- Maintenance (using weights)
- Feed intake (using MIR predicted feed intake)
- Methane emissions
- N use efficiency
- Lameness from sensors

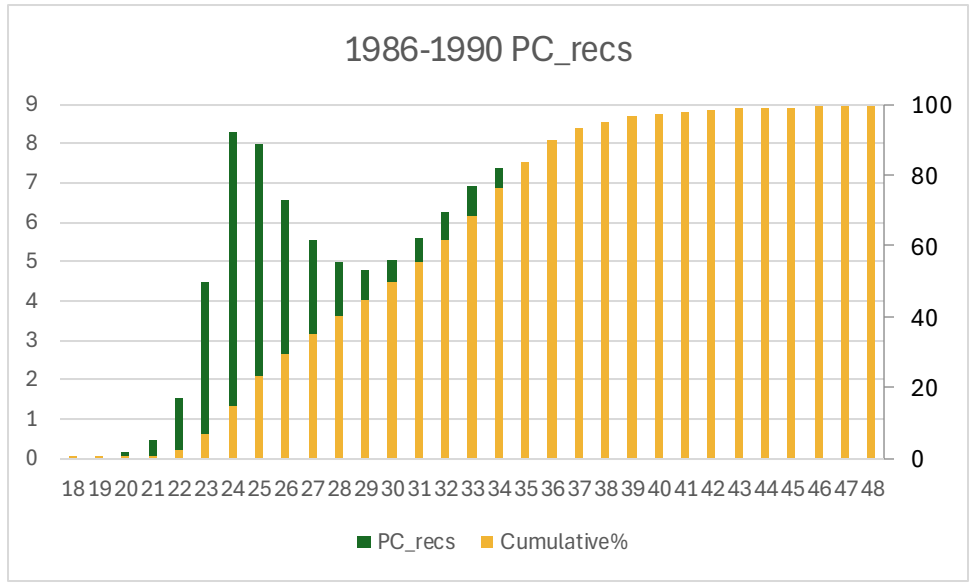
EnviroCow
Feed Advantage
Methane?
Johnes

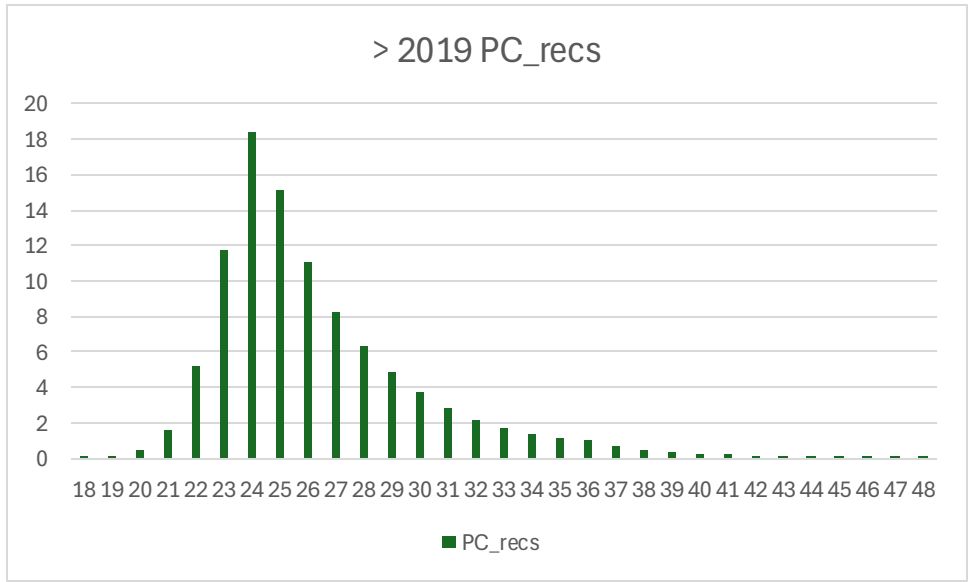
Daily lifetime yield per KG liveweight

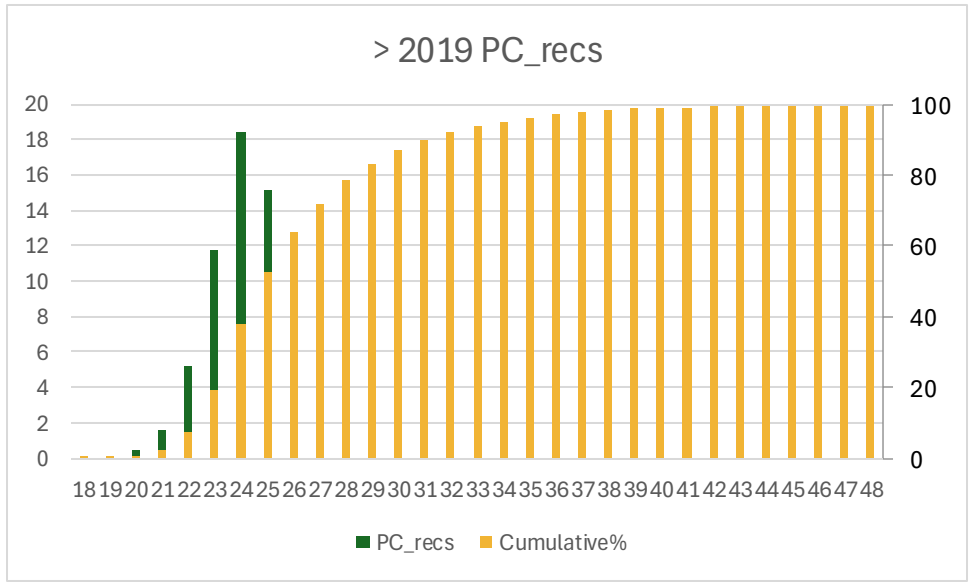
- DLY = (KGS Fat + Protein) per Day of life
- Efficiency = DLY per kg liveweight (derived from Maintenance EBV)




1986-1990 PC_recs
9
8
7
6
5
4
3
2
1
0
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
PC_recs


1986-1990 PC_recs
9
8
7
6
5
4
3
2
1
0
100
80
60
40
20
0
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
PC_recs
Cumulative%


> 2019 PC_recs
20
18
16
14
12
10
8
6
4
2
0
18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
PC_recs


> 2019 PC_recs
20
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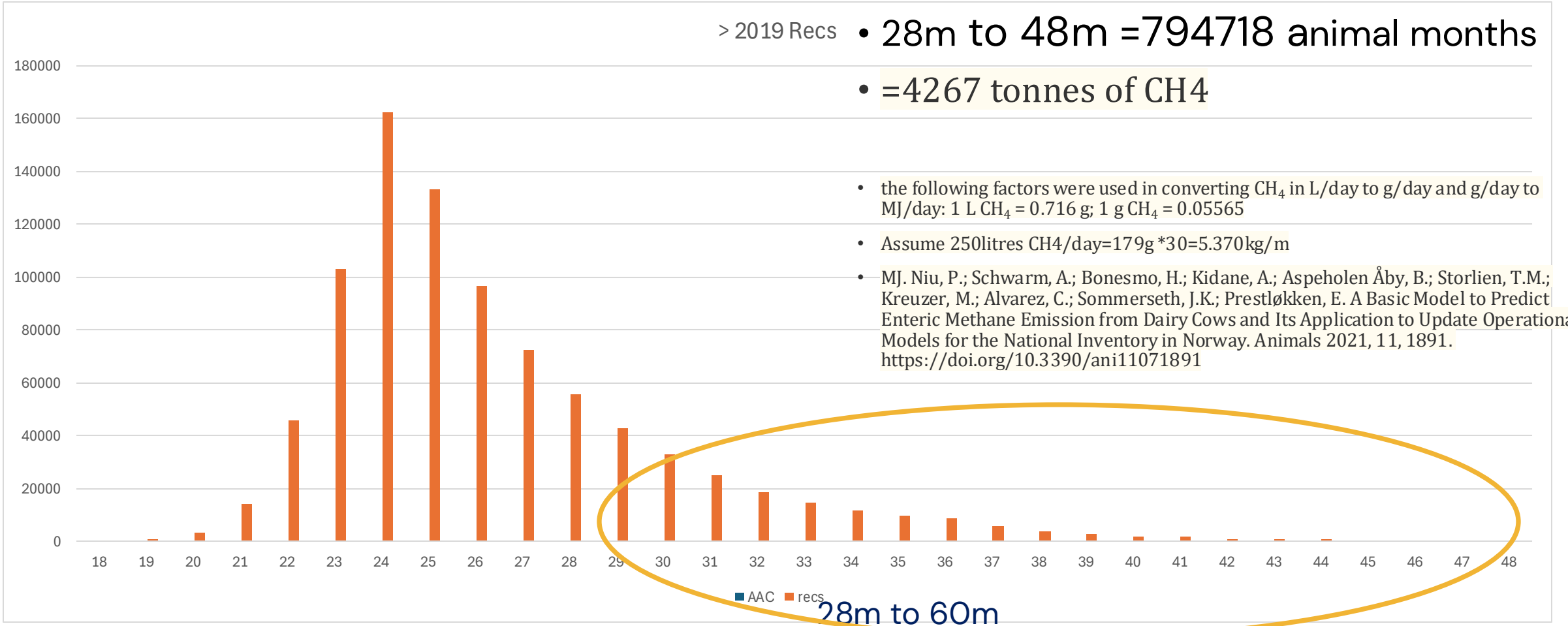
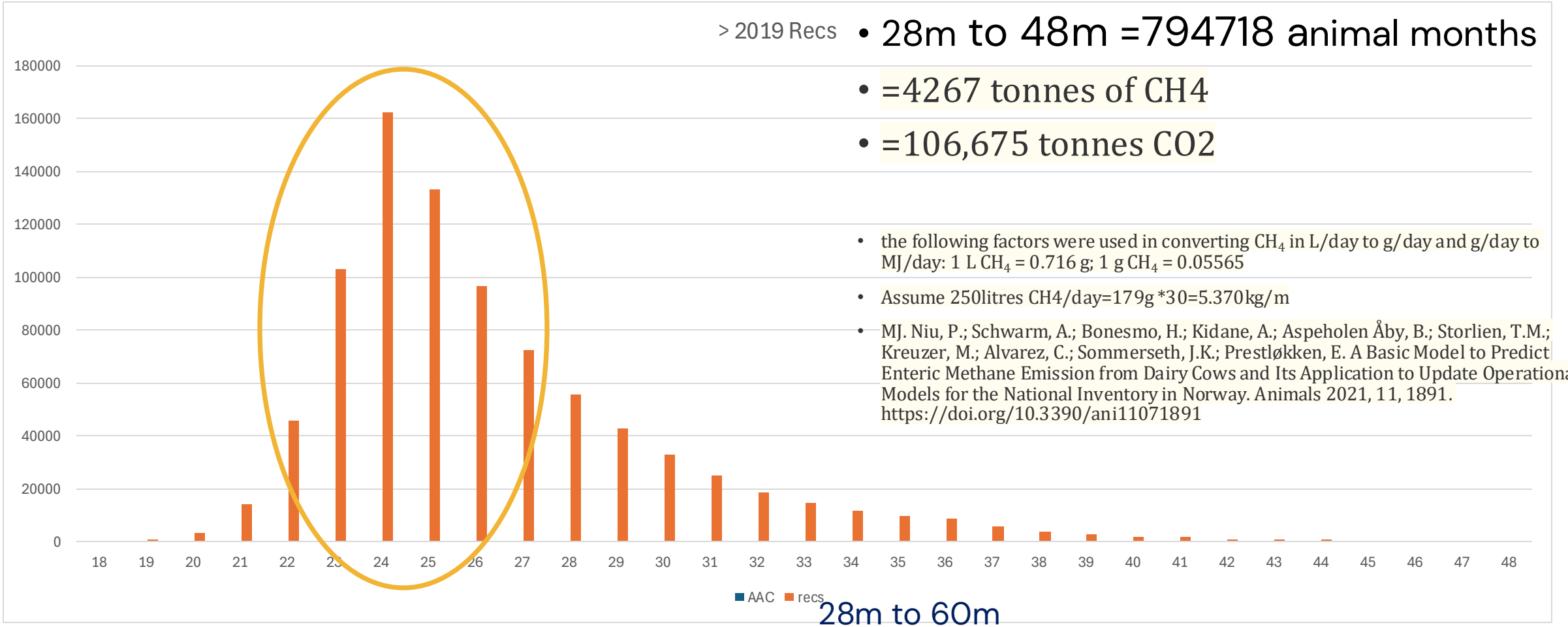
PC_recs
Cumulative%



- 28m to 48m =794718 animal months
- =4267 tonnes of CH4

- the following factors were used in converting CH_4 in L/day to g/day and g/day to MJ/day: 1 L CH_4 = 0.716 g; 1 g CH_4 = 0.05565
- Assume 250litres CH4/day=179g*30=5.370kg/m
- MJ. Niu, P.; Schwarm, A.; Bonesmo, H.; Kidane, A.; Aspeholen Åby, B.; Storlien, T.M.; Kreuzer, M.; Alvarez, C.; Sommerseth, J.K.; Prestløkken, E. A Basic Model to Predict Enteric Methane Emission from Dairy Cows and Its Application to Update Operational Models for the National Inventory in Norway. Animals 2021, 11, 1891. https://doi.org/10.3390/ani11071891

28m to 60m
843528 animal months = 4530 tonnes



- 28m to 48m =794718 animal months
- =4267 tonnes of CH4
- =106,675 tonnes CO2

- the following factors were used in converting CH_4 in L/day to g/day and g/day to MJ/day: 1 L CH_4 = 0.716 g; 1 g CH_4 = 0.05565
- Assume 250litres CH4/day=179g *30=5.370kg/m
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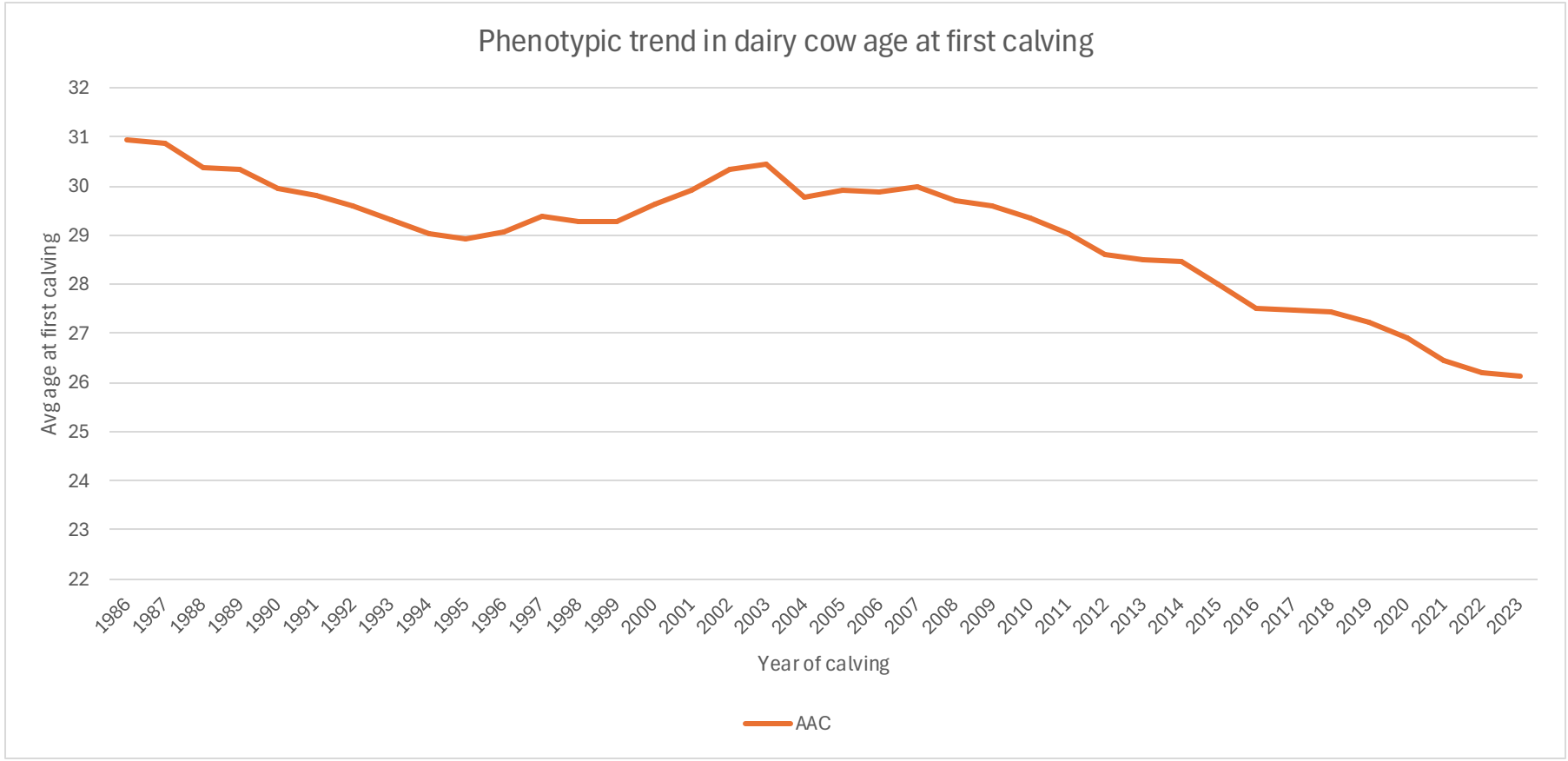
Phenotypic trend in dairy cow age at first calving
Avg age at first calving
32
31
30
29
28
27
26
25
24
23
22
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
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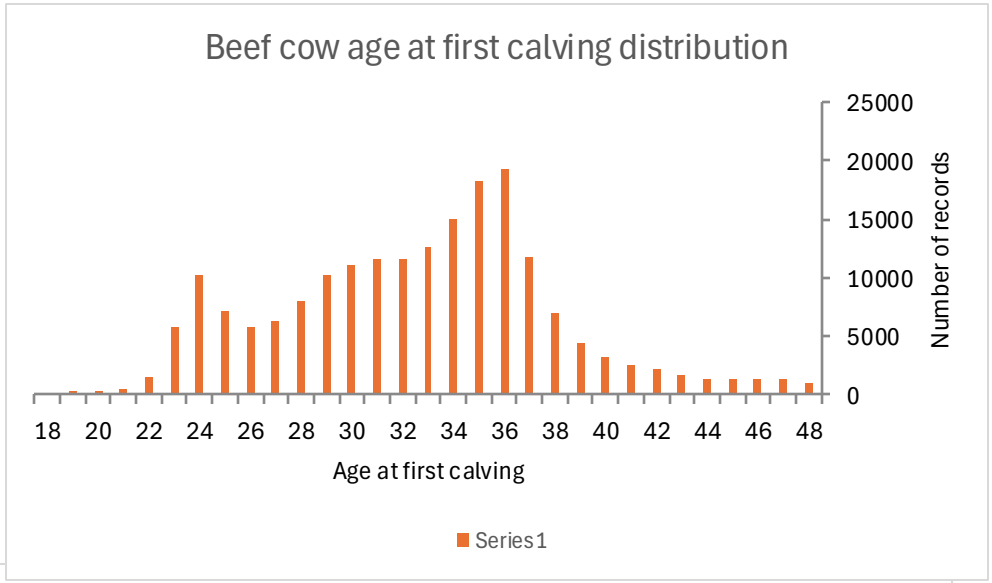
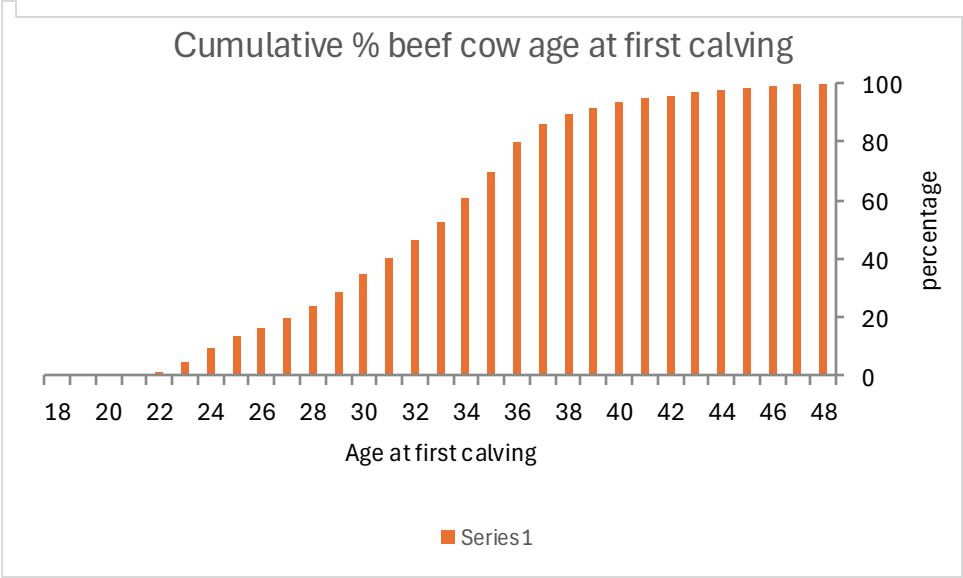
2019
2020
2021
2022
2023
Year of calving
AAC

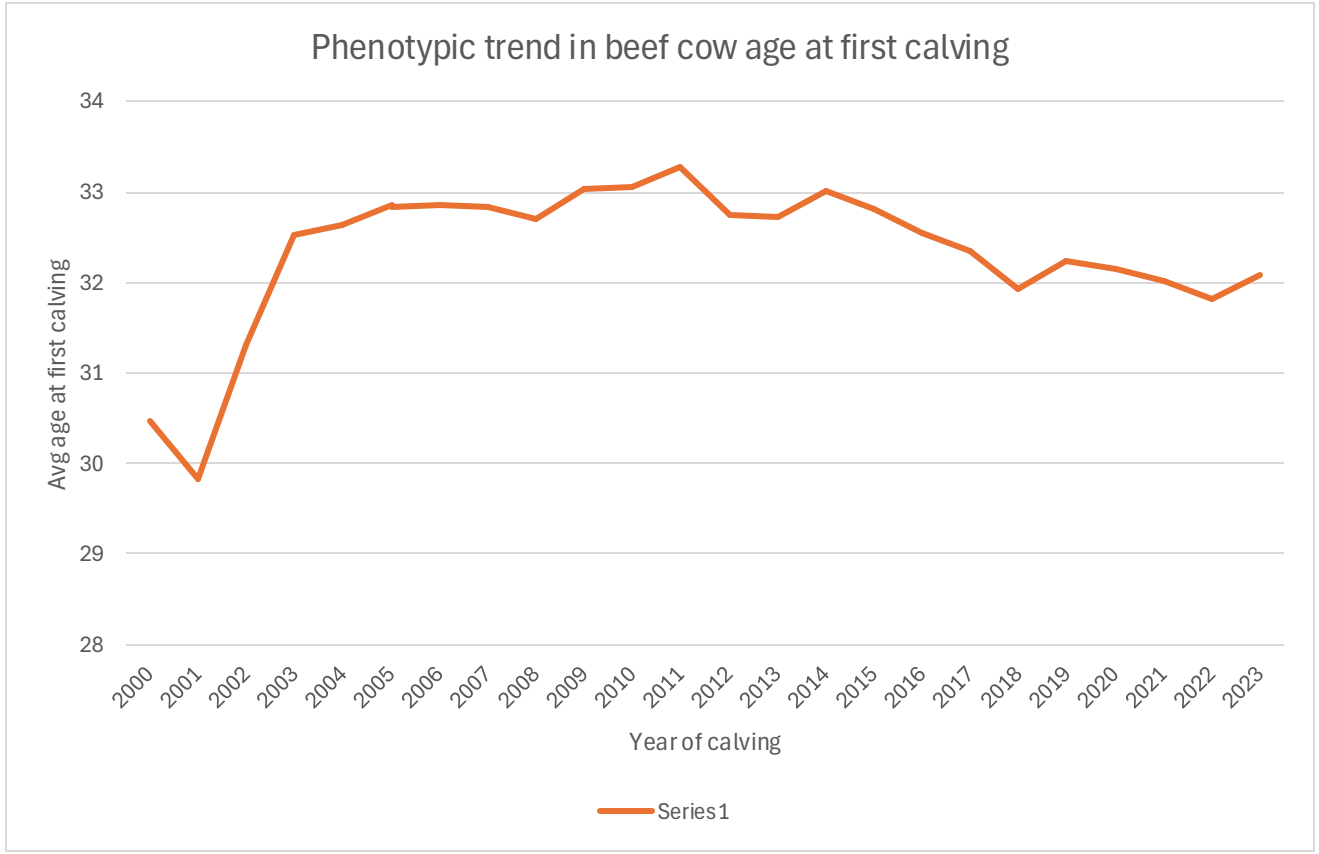




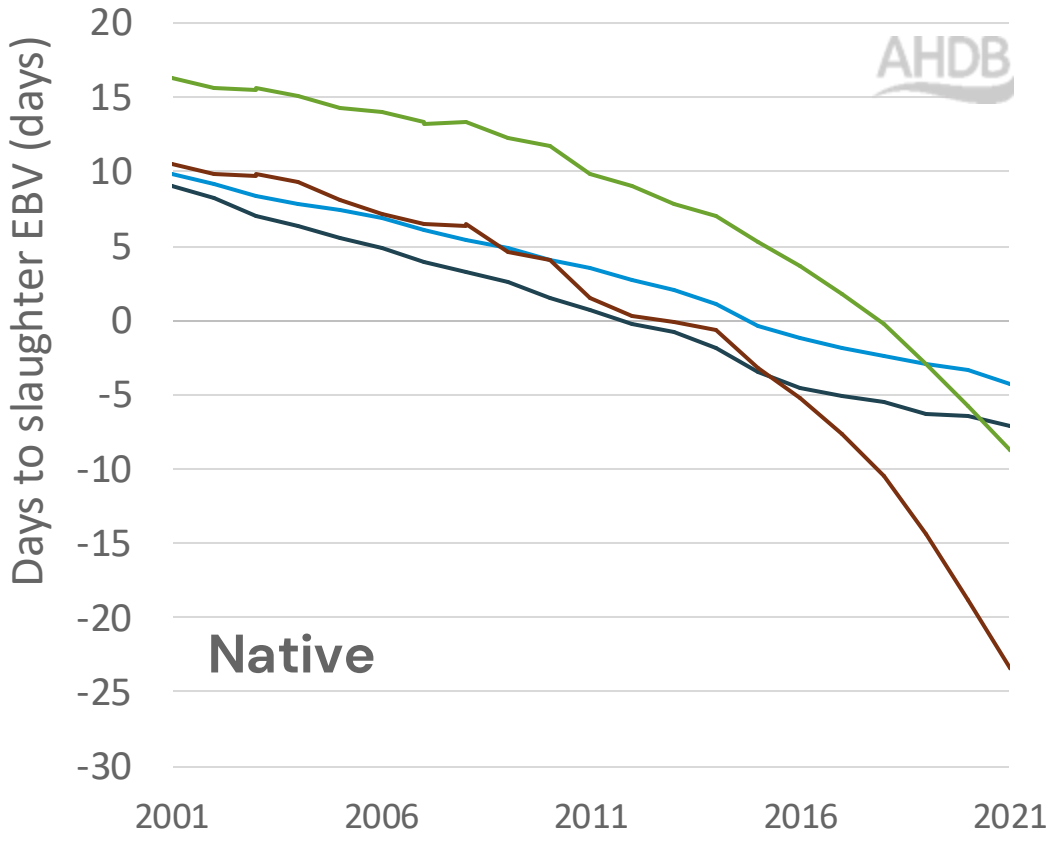
48m to 28m=-1017773 animal months

= 5465 tonnes CH4

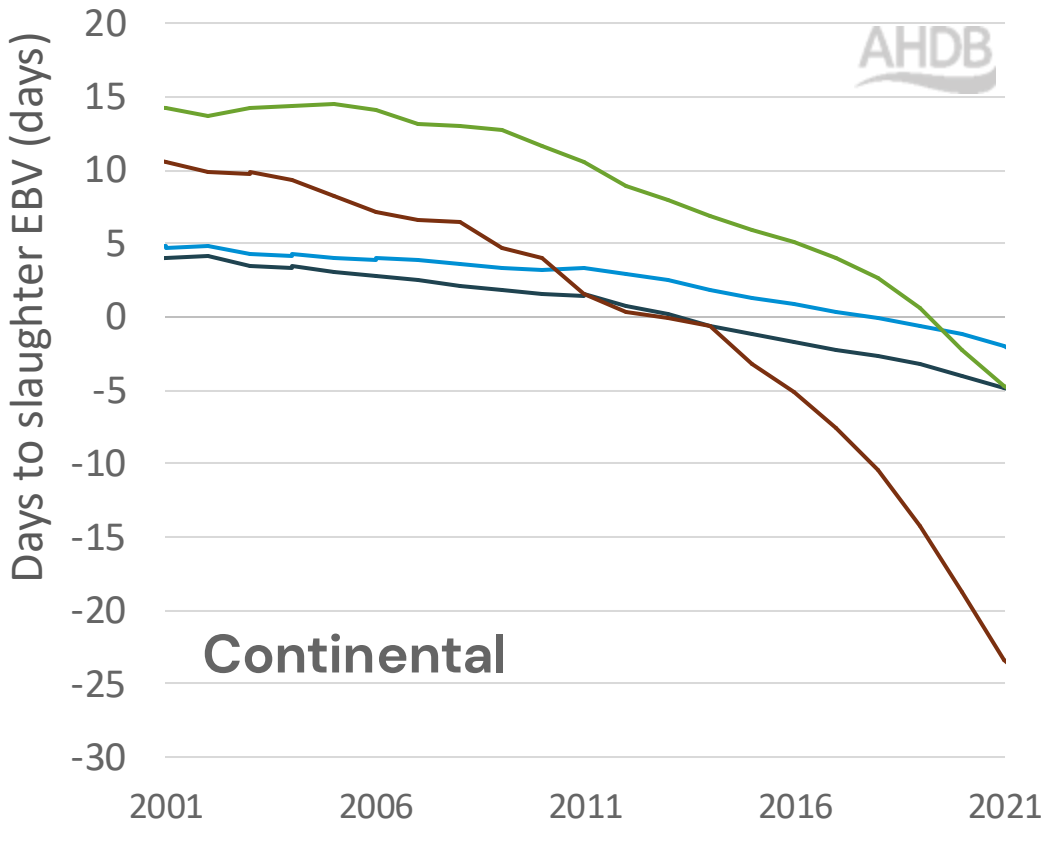
=136,625 tonnes CO2


Phenotypic trend in beef cow age at first calving
34
33
32
31
30
29
28
Avg age at first calving
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Year of calving
Series1

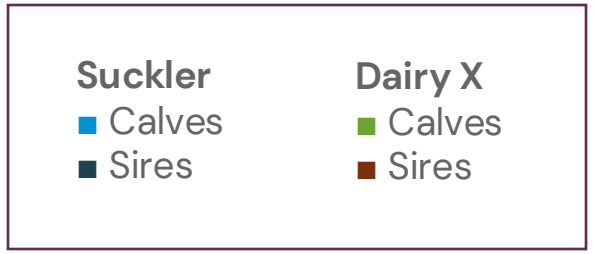
Speed of adoption!



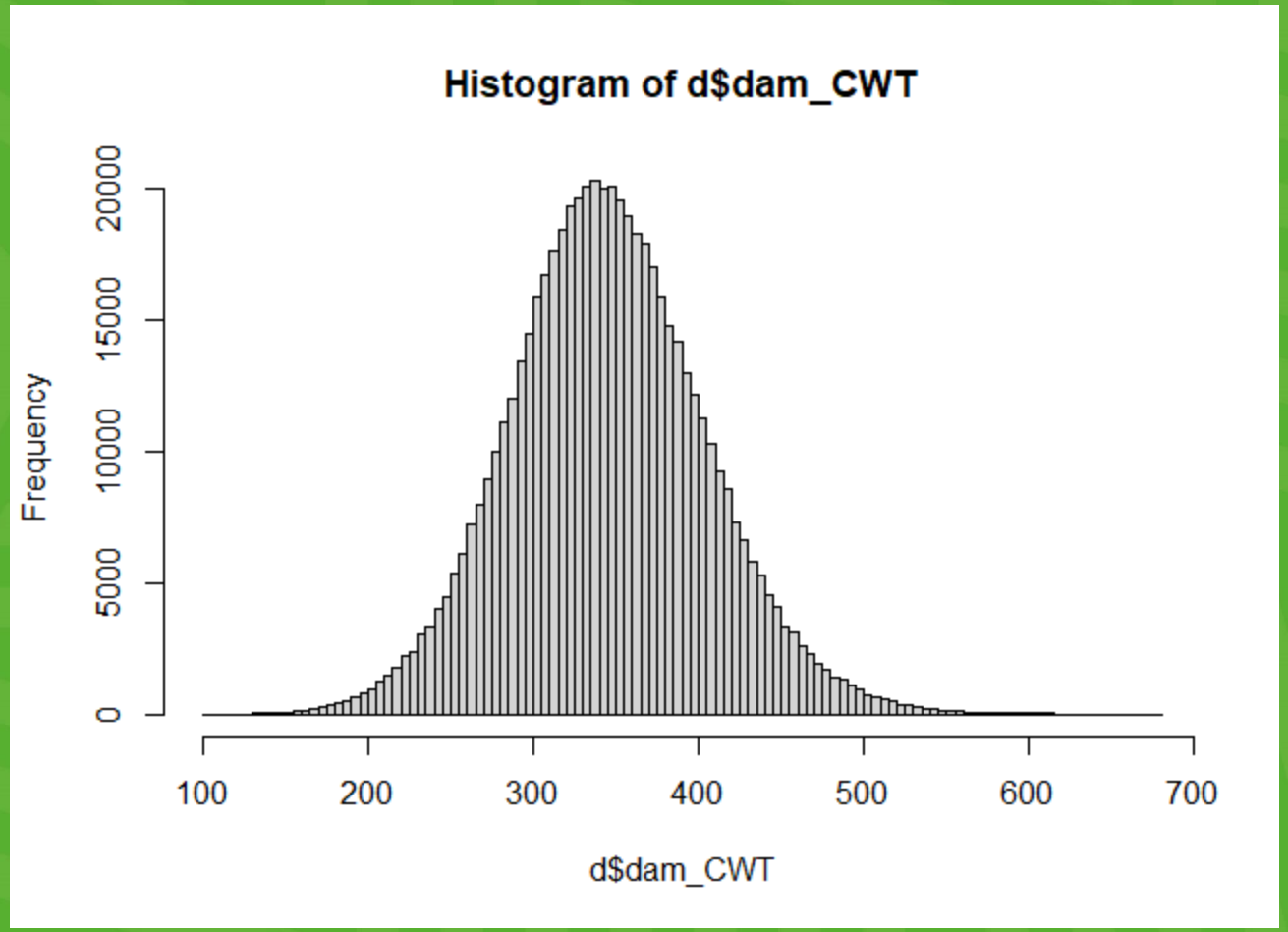
Source: AHDB National Beef Evaluations



Source: AHDB National Beef Evaluations

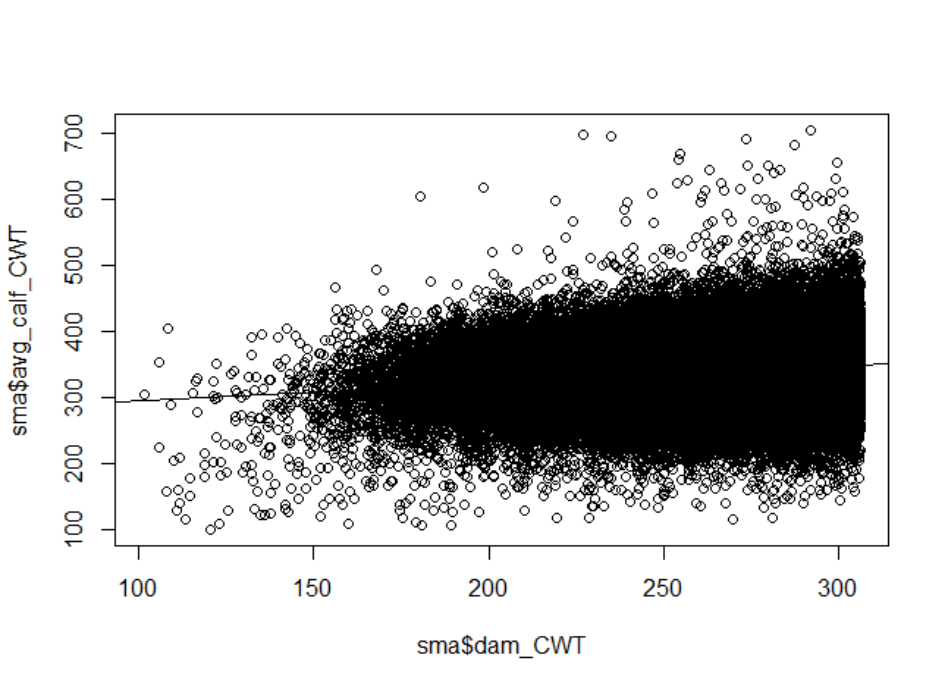


SRUC


Histogram of d$dam_CWT
Frequency
0
5000
10000
15000
20000
100
200
300
400
500
600
700
d$dam_CWT

CWT = carcass weight

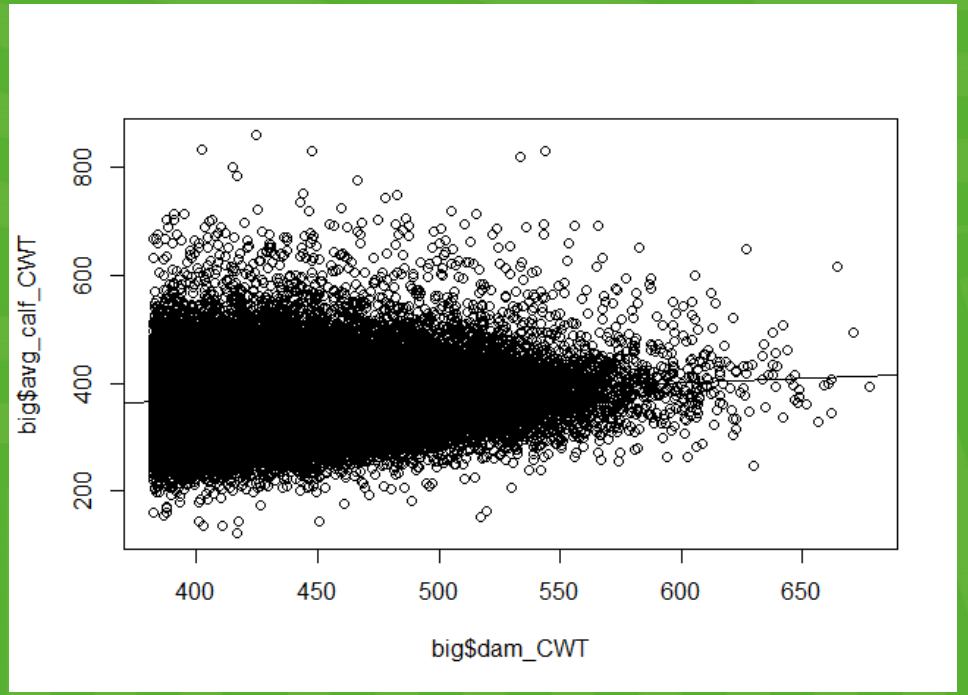
Small cows (CWT < 306kg)



Calf weight = 269 + 0.26 * Cow weight

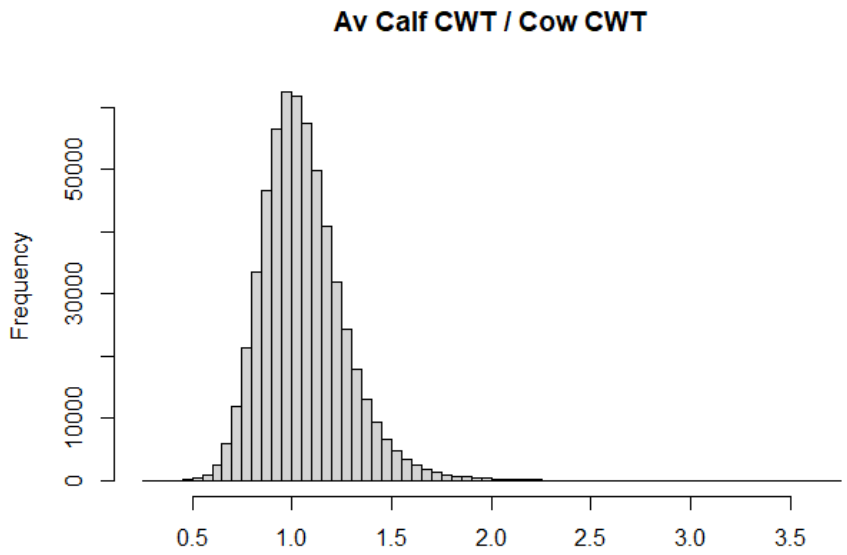
Mean (Avg calf weight / cow weight) = 1.26

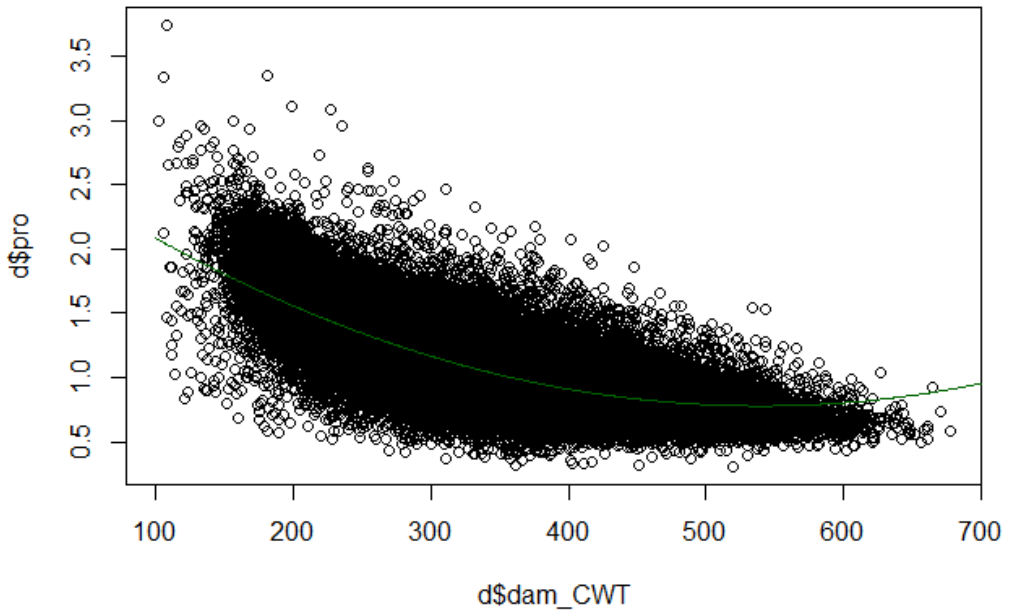
Big cows (CWT > 382kg)



Calf weight = 300 + 0.17 * Cow weight

Mean (Avg calf weight / cow weight) = 0.89





On average, smaller cows are more likely to produce higher calf carcase weights per kg of cow weight

The least efficient cows are at intermediate weights

Calves from dairy or beef dams

Dam Type	Avg net CWT Of calves	Avg conf Of Calves	Avg fat Of calves	Avg AAS Of calves	recs
Dairy	326	18.3	24.6	25.6	876339
Beef	356	25.5	25.8	23.1	913899
Beef +ve	+30kg	+1.2		-2.5m	

Condemnation data

(Liver fluke/lungworm)

- Reflects wastage of product
- Can be used to infer characteristics of farm/environment
- Could be used as a phenotype in a selection index
- Could be used to adjust existing breeding values to make more accurate

- Will definitely affect methane emissions metrics
- May be affected by climate changes
  - Warmer and wetter –> more worms

Where to next?

- Beef from dairy increasingly important
- Changes to dairy affect beef supply
  - Improved dairy cow feed efficiency
  - Better fertility in dairy -> more beef calves
  - Smaller dairy cows
  - etc

- Direct measures of methane
  - International collaboration projects now being established
  - US and UK are players
  - Pooling data is best option for rapid and widespread adoption and change
  - Market forces will slow it down
    - Some form of government intervention required on behalf of society
    - Farmers will have to be willing players or else ….

Real-time phenotyping: Scalable deep learning for CT scan segmentation and image analysis

Phivos Sofokleous
Dr Mazdak Salavati
Prof Mike Coffey

SRUC

NVIDIA | DEEP LEARNING INSTITUTE

Fastbreeders

SRUC

- Accelerated improvement of crossbred dairy cows using OPU/ET
- JerseyRoyalBeef.com
- Measuring cow liveweight for net zero milk production
- Measuring everything possible to improve

SRUC

The future

Its not what it used to be

- In the foreseeable its great!
- Lots of low hanging fruit
- Easy to deploy
- Easy to monitor and publicise
- Future is bright

- Breed early using high efficiency bulls
- Smaller healthy cows
- Waste less calves
- Grow fast
- Process quick

- Integrated supply chains?

Summary

We have enough NOW to improve sustainability

We don’t need to wait for direct measures of methane

Direct measures will allow refinement but are not a barrier to starting

- Tools are available to make a start
  - Fertility measures
  - Age at first calving
  - Age at slaughter
  - Cow/Calf survival
  - Size of suckler cow
  - Size of dairy cow
  - Feed intake
- Data already exists to monitor progress in UK and many countries
  - National abattoir data
  - National cattle registration and movements data
- New data will allow us to refine GHG measures used
  - Rumen microbiome
  - Methane sensors

Acknowledgements

- Scottish Government Strategic Research Programme for funding
- UK meat processors for abattoir data
- UK Government Animal and Plant Health Agency for cattle movements data
- AHDB for national evaluations funding

In the end…

I genotypens ålder är fenotypen kung

Im Zeitalter des Genotyps ist der Phänotyp König

#PHENOTYPE IS KING!

En la era del genotipo …
¡El fenotipo es el rey!

Genotyypin aikakaudella fenotyypi on kunigas

Genotyyppiaikakaudella fenotyyppi on kuningas

Fenotype blijft de koning

في عصر التركيب الجيني
البيانات المظهرية هي الملك

فینوٹائپ بادشاہ ہے

Την εποχή του γονοτύπου, ο φαινότυπος είναι βασιλιάς!

ADCG = average daily carcass gain; CWT = carcass weight; AAS = age at slaughter

Total calf ADCG = N offspring * (avg_CWT / avg_AAS)

Total cow (maintenance) cost = dam_CWT * *dam_AAS*

Total efficiency = total ADCG per kgday of cow weight