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Only 100% to share – breeding objectives revisited for improved sustainability and animal welfare

Birgit Fuerst-Waltl[1], Alfons Willam[1], Christa Egger-Danner[2] and Christian Fuerst[2]

[1] Institute of Livestock Sciences, BOKU University, Vienna, Austria

[2] ZuchtData EDV-Dienstleistungen GmbH, Vienna, Austria

Overview

- **Background**
- **General aspects**
  - Breeding objectives and traits
  - Total merit index
- **Practical example**
  - Traits, weights and (expected) selection response in Fleckvieh
- **Balanced breeding – now and then?**
  - Several indices (breeding objectives?)
  - (Partly) missing traits
  - Too many traits already?
  - Concluding remarks

Focus on dairy and dual purpose cattle

Background

- **Breeding** focused on **production** and **conformation** for a long time
- **Functional traits followed**
  - to mitigate negative side-effects of focussing on performance,
  - to meet new socio-political demands,
  - and to increase profitability
- **Increasing** number of **traits** considered at the same time

- **Index selection was/is key**
  - Weighting of traits according to their relative (economic) importance
- **Modern technology** enabled speeding up **genetic progress**
  - Data recording and availability
  - Computing capacity
  - Genomic information

Further extension towards more sustainability and animal welfare demanded – breeding objectives get even more complex

General aspects

Steps in breeding

Breeding objective

⇩

Performance testing

⇩

Genetic evaluation

⇩

Selection

⇩

Genetic gain

Aim of breeding is genetic gain for traits defined in the breeding objective

Steps in breeding

Breeding objective

⇩

Performance testing

⇩

Genetic evaluation

⇩

Selection

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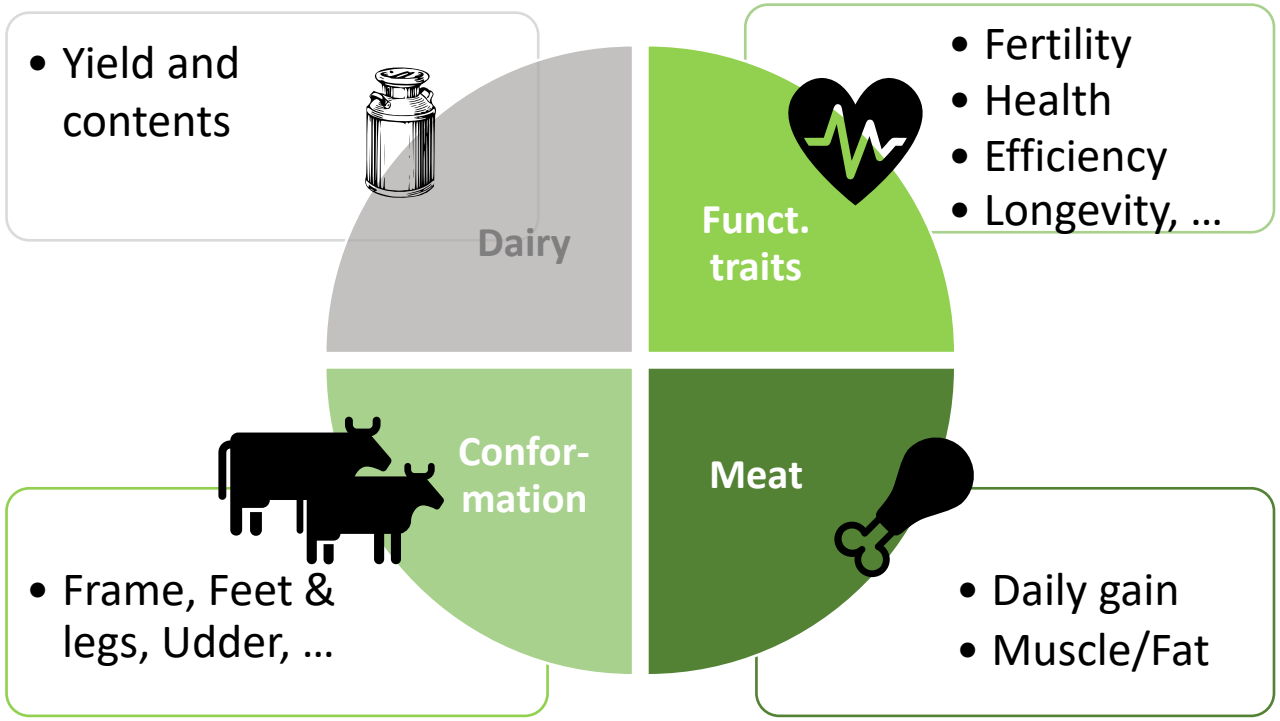
Genetic gain

Which way to go?

Which traits shall be considered (simultaneously)?

For example in milk producing animals:



Total merit index (TMI)

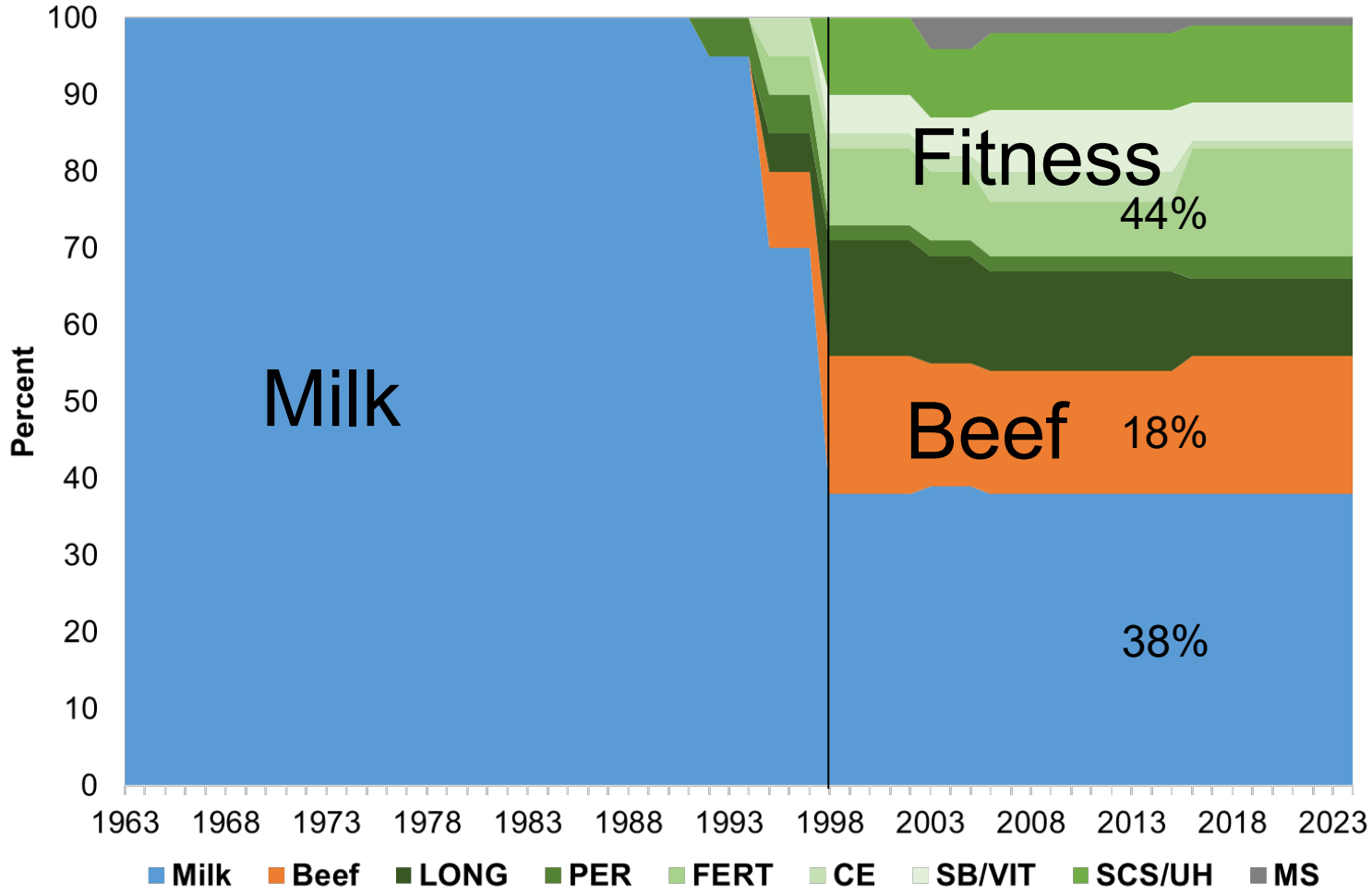
- **Mathematical definition** of the breeding objective
- **Combines** traits and trait complexes, **weighted** in accordance to economic importance
- Should consider **future conditions**
- Objective **ranking** according to **overall genetic value**

- **Higher relative weights – higher potential genetic gain**
  - Dependent on heritability/ reliabilities/correlations to other traits

More traits – less relative weight on each of them →
selection response **reduced** for single traits in case of **antagonistic relationships**

Practical example – traits, weights and (expected) selection response in Fleckvieh

Fleckvieh – genetic evaluations and TMI



1995 Funct. longevity, beef, fertility, calving ease

1998 GZW (TMI)

2002 AT+DE; SCC, milkability

2006 GZW new

2010 Health; genomics

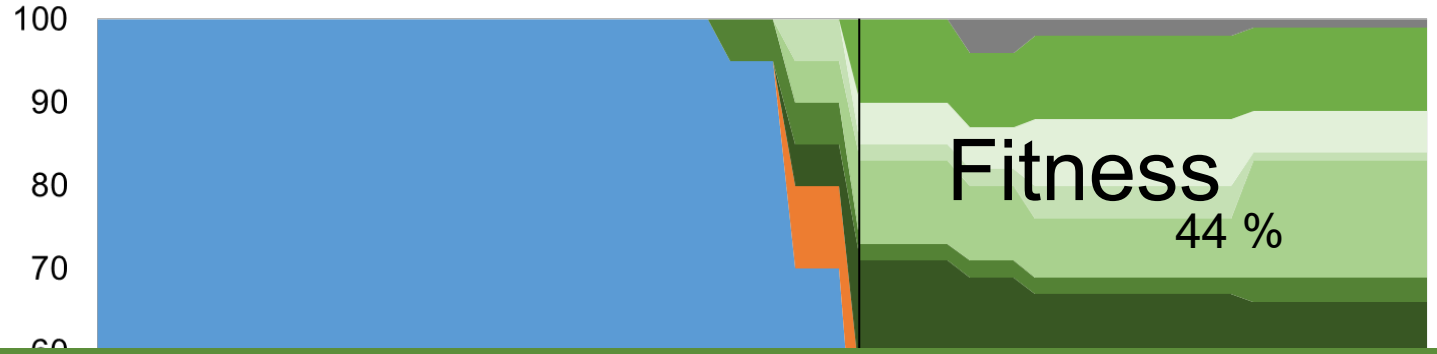
2016 AT+DE+CZ; GZW new, calf vitality

2017 ÖZW (TMI for organic prod.)

2021 Single-Step

2023 Claw health

Fleckvieh – genetic evaluations and TMI



1995 Funct. longevity, beef, fertility, calving ease

1998 GZW (TMI)

2002 AT+DE; SCC, milkability

Conformation indirectly, **Claw health not yet** in TMI

Work in progress: Metabolic stability, liveweight/efficiency, methane emissions

Planned: Calf health and behavioural traits, heat tolerance/resilience

Latest change in breeding objective in 2016

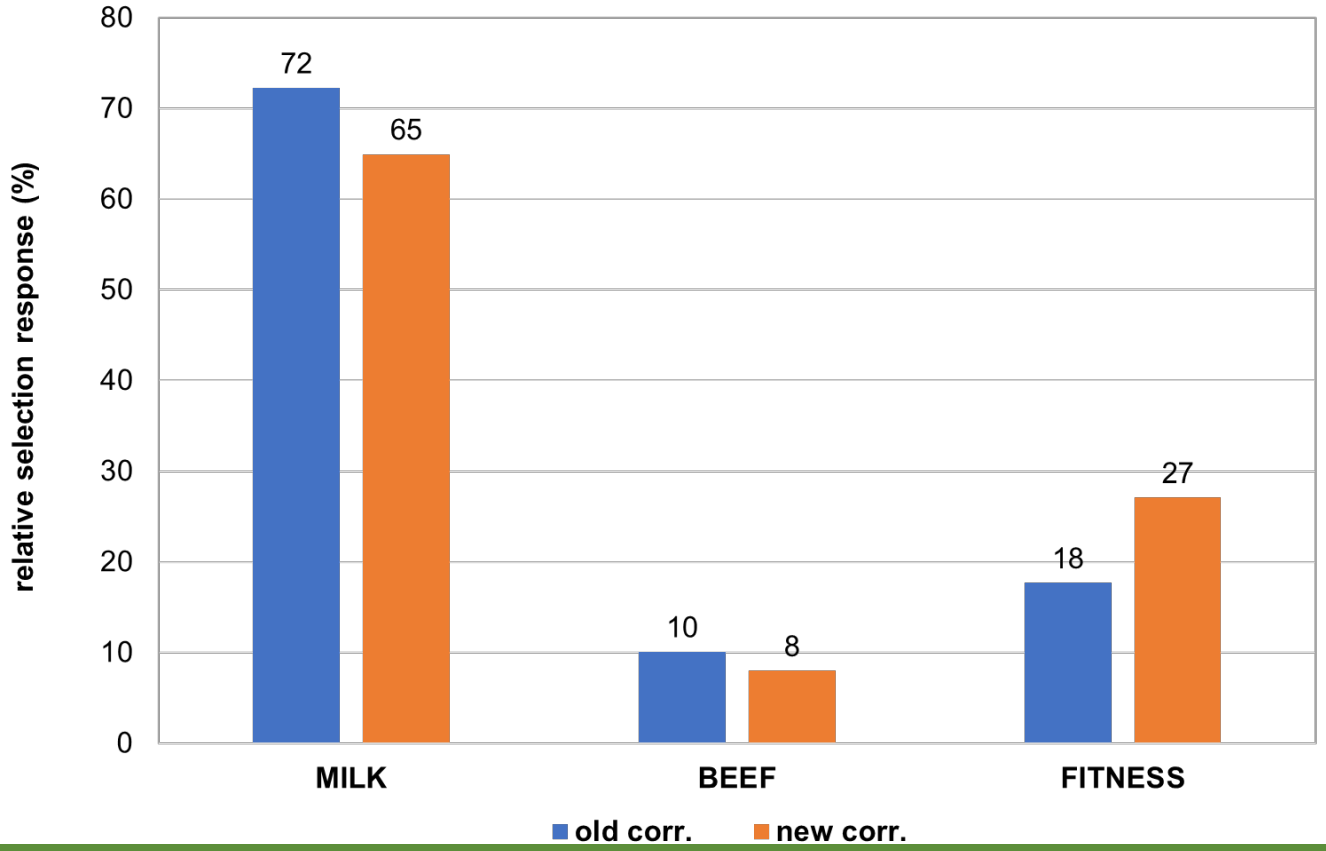
- **Survey among farmers** (new traits, personal breeding objectives, …)
- Derivation of **economic values,** estimation of **genetic correlations**
- **Discussions** between genetic evaluation team/science, breeders and breeders' representatives

Consensus based on **combination** of derived **economic values** and **selection response**

Cooperation between science, breeding organisations and breeders is time intensive but vital for acceptance

Selected selection response scenarios

Updating genetic correlations



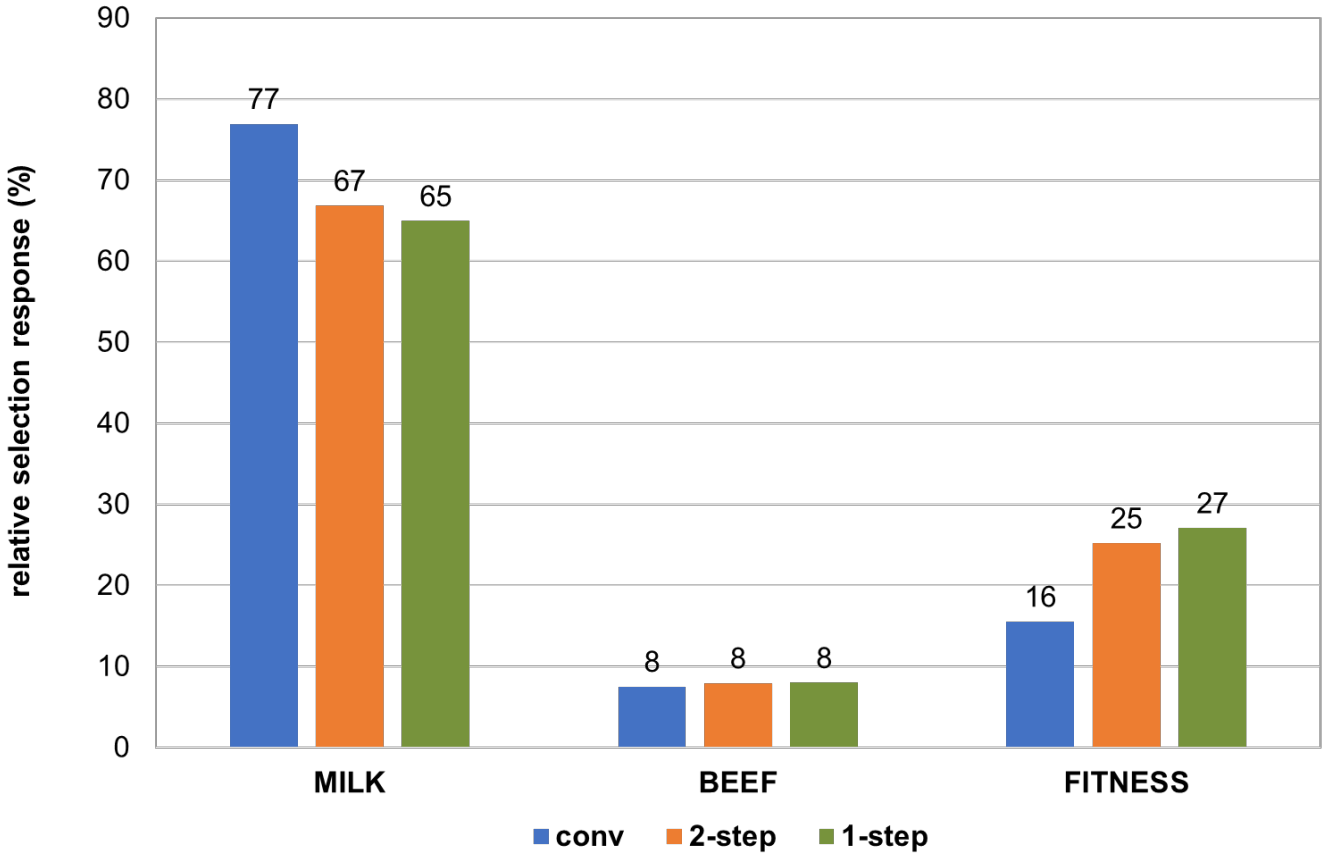
Scenarios – Current methodology (Single Step) and weighting (38:18:44) with **genetic correlations before** and **after 2016**

- within functional traits more synergistic
- between functional traits and production more antagonistic

Strong effect of genetic correlations, regular revision advised

Selected selection response scenarios

Impact of genomic evaluation

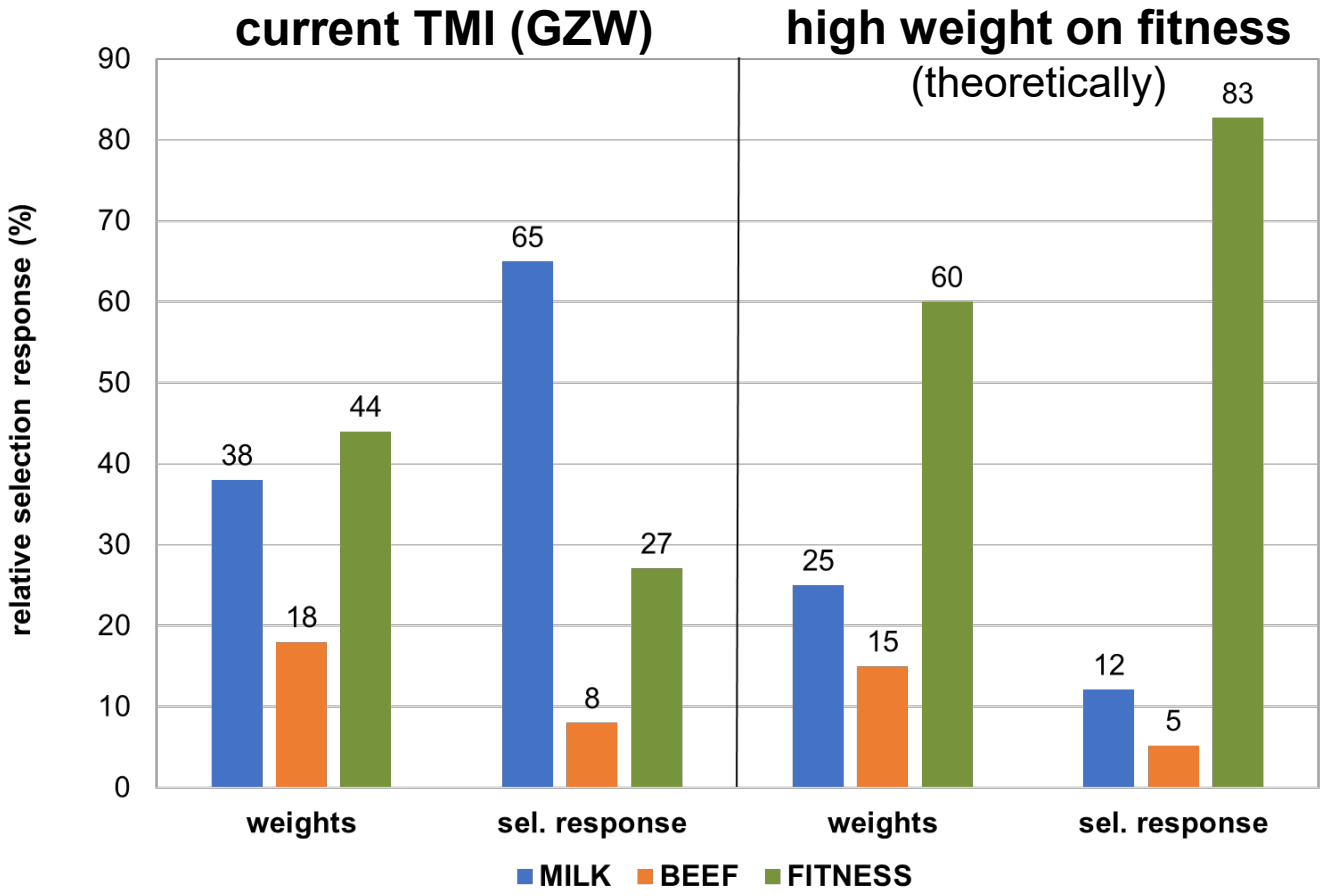


Scenarios – Current weighting (38:18:44) and reliabilities of **conventional**, **2-step** and **single step** evaluation

Strong effect of genomic/single step evaluation

Selected selection response scenarios

Higher weight on functional traits

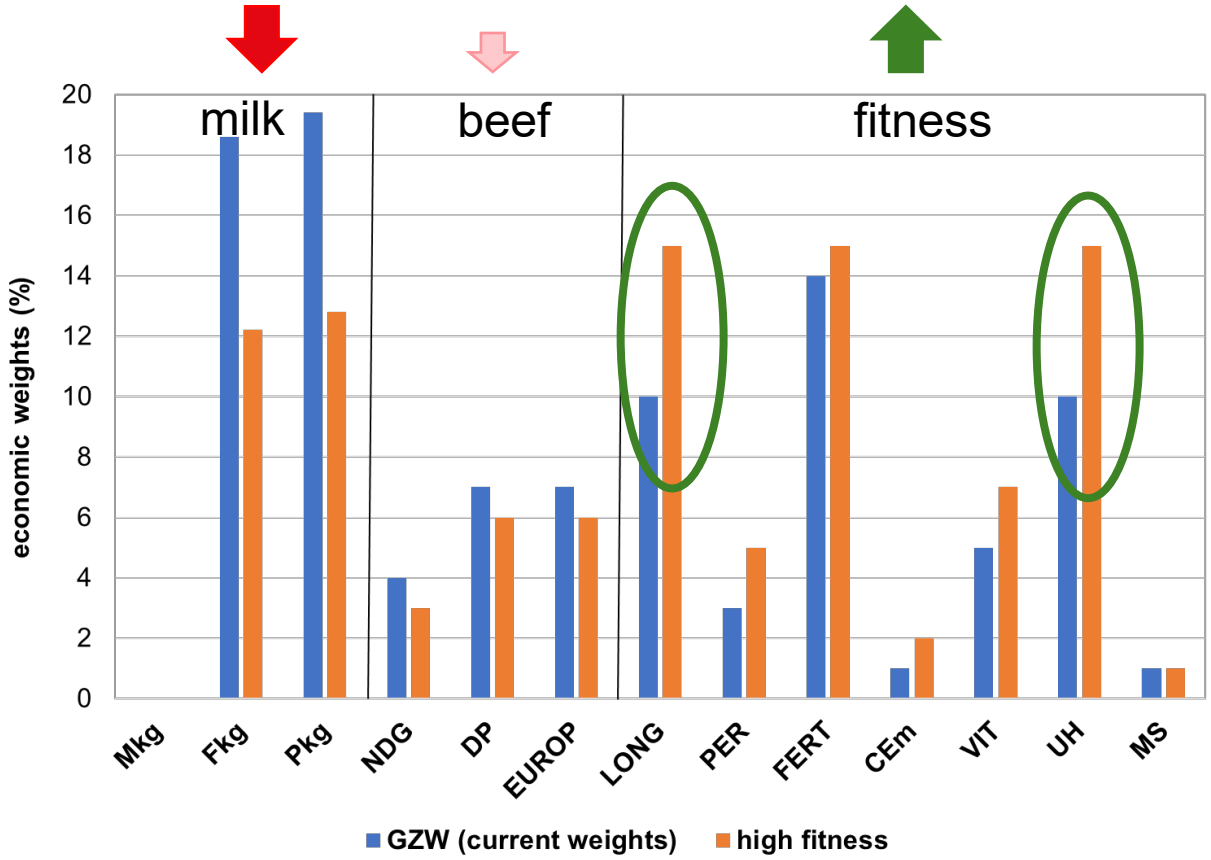


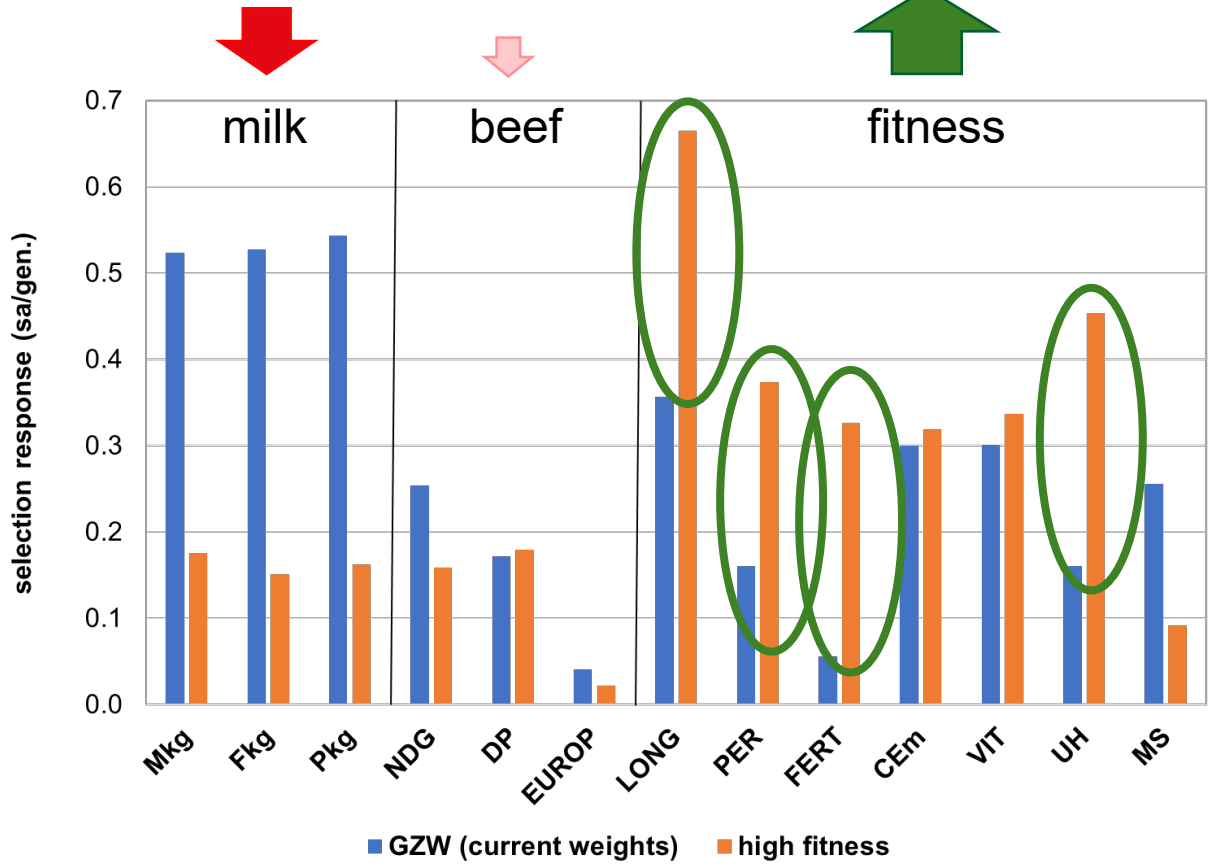
Scenarios – Current methodology (single step) **and current weighting** (38:18:44) vs. **high weight** on **functional traits** (25:15:60)

BUT: monetary genetic gain overall only 86% compared to scenario with original weights

Selected selection response scenarios

Higher weight on functional traits – effect on traits/trait complexes





If reliabilities of functional traits are high (genomics), higher weights can result in remarkable genetic gain

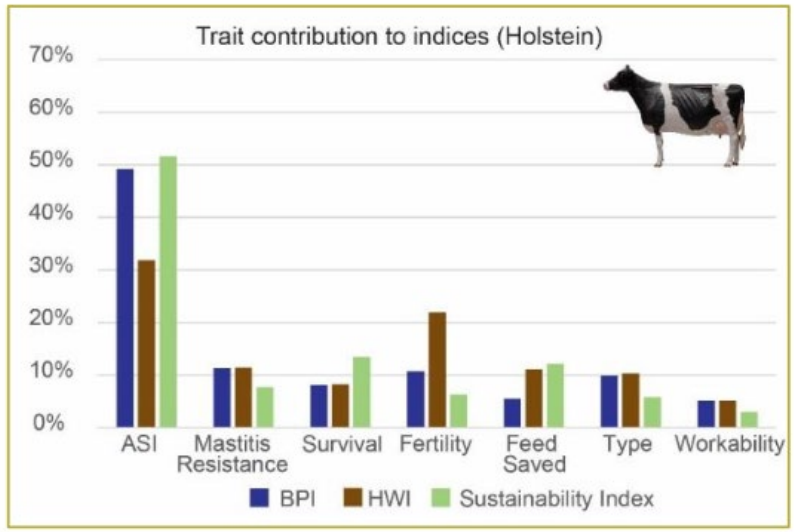
Balanced breeding – now and then?

Several indices (breeding objectives?)

- Approach in some populations **is creating different** overall indices
  - Focus on economics
  - Focus on trait groups that are important for different players
- Some re-ranking obviously occurs
- Way to **address different interest groups**

- As long as **goals are not contradictory**, a valid approach
- Alternatively, **mating programmes** where breeders can give in their options for different traits/trait complexes

Different indices, Holstein



Australia: Balanced Performance Index, Health Weighted Index, Sustainability Index
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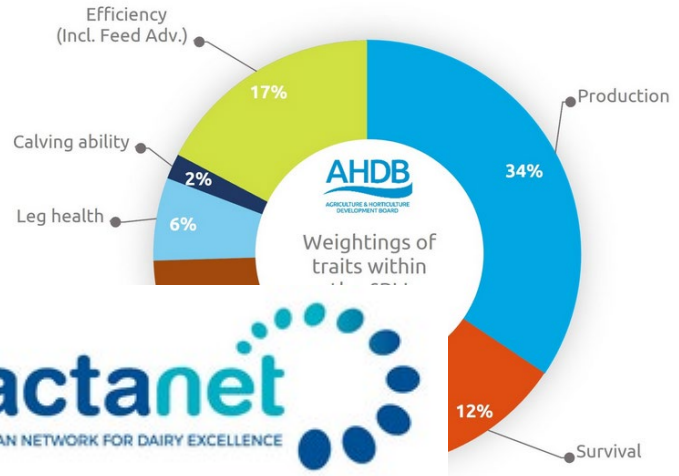
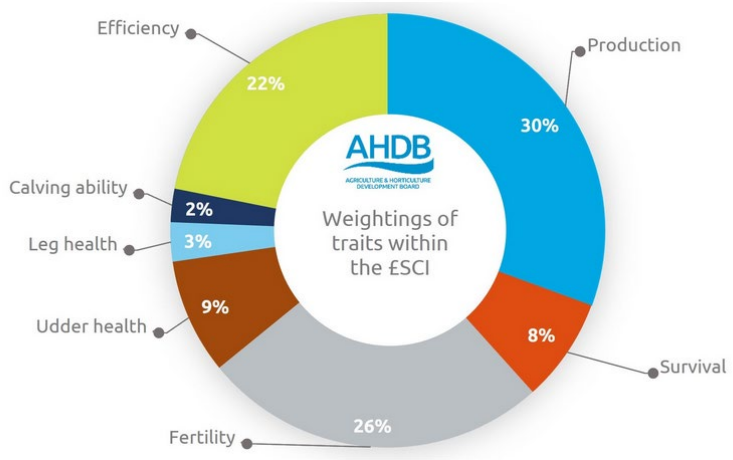
UK: £PLI (Profitable Lifetime Index), **SCI** (Spring Calving Index) and **ACI** (Autumn Calving Index)





Canada:
LPI: Lifetime Performance index (40% production, 40% Durability, 20% Health and Fertility)
Pro$: Profit-Based Genetic Selection Index
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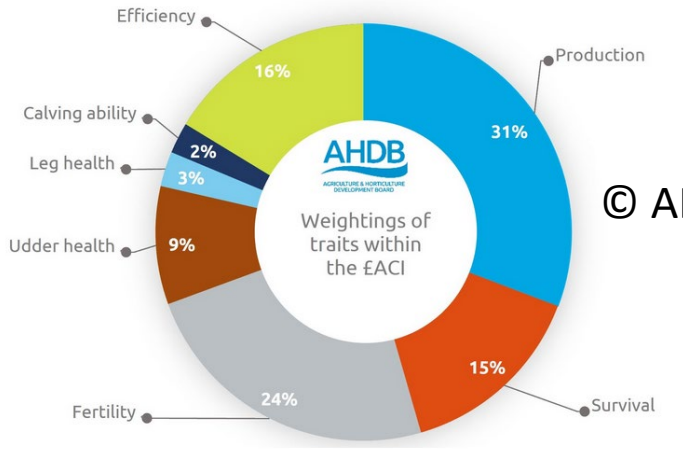

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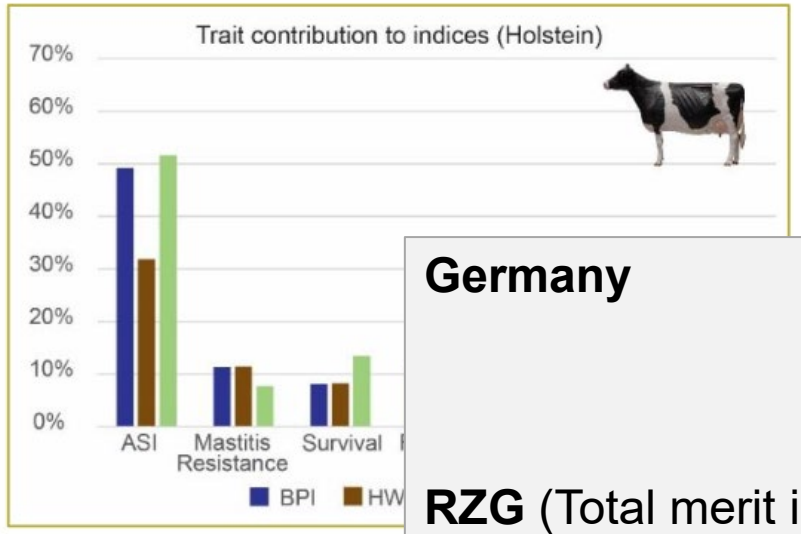
Different indices, Holstein



Germany ©

RZG (Total merit index)
RZÖko (Total merit index for organic farming)
RZ€ (On the marginal profit scale in €)

Australia: Balanced
Index, Health Weighted Index,
Sustainability Index
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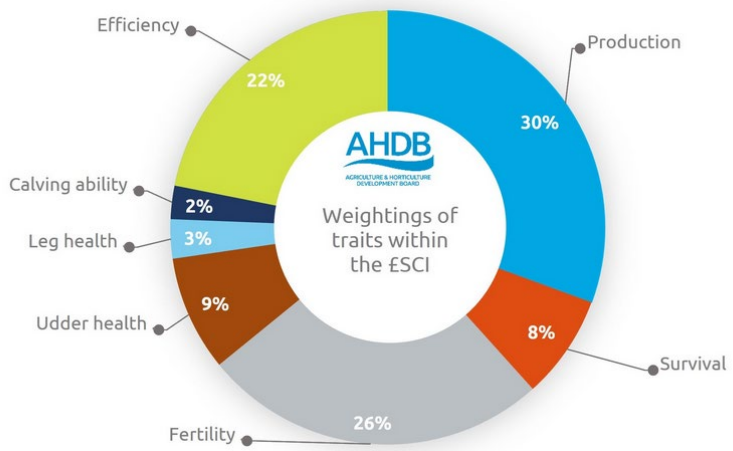
UK: £PLI (Profitable Lifetime Index), **SCI** (Spring Calving Index) and **ACI** (Autumn Calving Index)



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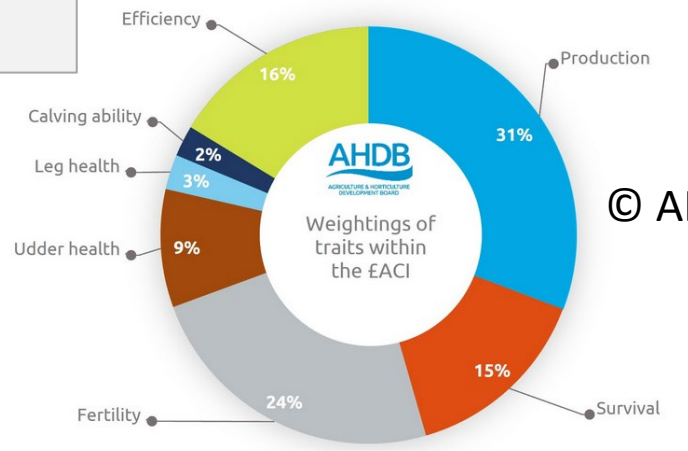

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Today's breeding objectives/TMIs
rarely purely economic –
socio-political aspects already often considered

Tendency worldwide for **more balanced breeding objectives**

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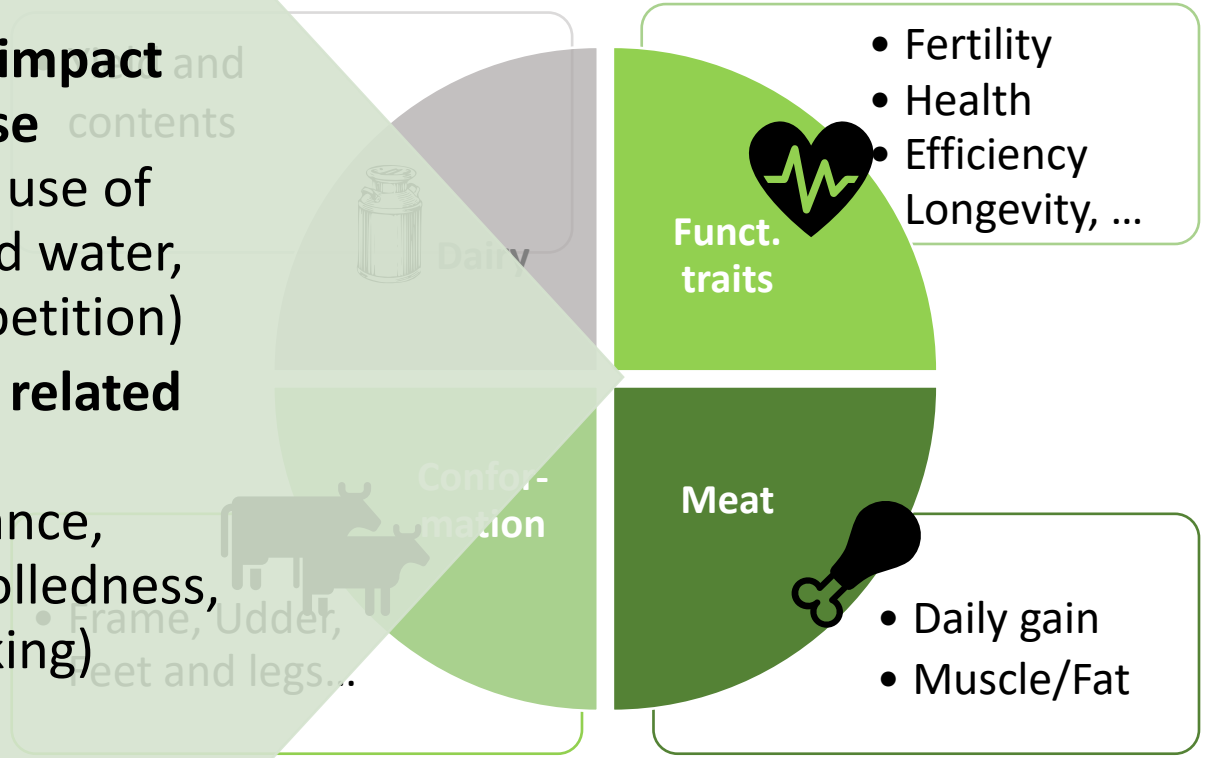
More and more **traits reflecting sustainability** and **welfare** have already found their way into breeding –
some however (partly) missing

(Partly) missing traits

(Partly) missing sustainability and welfare related traits?

- **Environmental impact and resource use** (e.g. emissions, use of land, energy and water, feed/food competition)
- **Animal welfare related traits** (e.g. heat tolerance, calf diseases, polledness, cross-/intersucking)



Discussion – too many traits already – all missing ones to be included? How?

- Well considered by **pre-selection** or **mating strategies?**
  - Hereditary defects
  - Polledness
- Partly already **considered indirectly**?
  - Resilience/heat tolerance
- Might get **too much attention** when selecting bulls?
  - Twinning rate
  - Sucking deficiency
- Are difficult/expensive to measure?
  - Feed intake
- Have **no direct economic impact**

Question of breeders: we only have 100% to share – if new traits are included, for which traits do we reduce weights? Which effect does it have?

Discussion – too many traits already – all missing ones to be included? How?

- **New traits included** affect others, depending on genetic correlations and reliabilities
- **New traits coming, others going?** Careful evaluation of the traits needed
- If no economic values derivable, application of **desired gain/expected selection response** approaches
- **Weighting performance traits:** Considering health, welfare and resource-related constraints, how much increase is possible or wanted?
- **Cooperations across countries** and/or **use of indicator traits** help to overcome problems of data availability and costs (e.g. MIR, data from automation)

Concluding remarks

- **Sustainability in breeding** includes many aspects, e.g.
  - Continuous income for farmers
  - Health and welfare for animals, health and well-being for farmers and consumers
  - Impact on environment (negative – e.g. emissions, positive – e.g. biodiversity)

- **Revision** of breeding objectives to make them **more sustainable** is inevitable

- **Needed to facilitate successful implementation**
  - **Sound scientific work**, use of multiple data sources and the most **modern methods**
  - **Openness** for discussions and changes
  - **Participation** of all those involved

Thank you – room for questions!

References

Information from the following websites:
Agriculture and Horticulture Development Board AHDB ahdb.org.uk
DataGene www.datagene.com.au
ICAR www.icar.org
Lactanet lactanet.ca
Rinderzucht AUSTRIA www.rinderzucht.at
Vit Verden www.vit.de

Selected Publications:
Burns et al. 2022 Animal 16:100535
Cole et al. 2021. J Dairy Sci 104:5111
Fuerst-Waltl et al. 2016. J Dairy Sci 99:9796
Goddard 1998. J Dairy Sci 81:6
Gonzáles-Recio et al. 2020. J Dairy Sci 103:7210
Groen et al. 1997. Livest Prod Sci 49: 1
Hazel 1943. Genetics 28:476
Hazel and Lush 1942. J Hered 33:393
Just et al. 2018. J Dairy Sci 101:5207
Miglior et al. 2005. J Dairy Sci 88:1255
Miglior et al. 2017. J Dairy Sci 100:10251
Richardson et al. 2024. JDS Communication in press
Shook 2006. J Dairy Sci 89:1349
Van Staaveren et al. 2022 J Dairy Sci 107:1510