Selection for feed efficiency in pigs: achievements and outlook

SABRE-TP Workshop 2022

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Outline

- **Feed efficiency in the Swiss pig breeding program**
  - Performance test and implication for feed efficiency traits
  - Achievements with selection on food conversion ratio (FCR)
  - Switch from FCR to feed intake per test day (DFI)
- **Outlook**
  - Alternative selection traits
  - How do we feed our pigs in the future (G x E) ?

Performance test in the testing station Sempach

- Test period defined by weight: 35-110kg
- 10-12 pigs per pen
- Ad lib feeding on feeders with RFID
- 2 feeds: growing & finishing
- Weight at start and end of test
- Daily feed intake (each visit in raw data)
- Weekly slaughterings in commercial slaughterhouse Sursee
- Carcass composition by AutoFOM (lean meat content)
- Meat and fat quality traits evaluated on samples in SUISAG meat lab

Traits related to feed efficiency

- Weight gain: 35 to 110 kg = fixed
- Days on test measures growth rate
- Feed consumed during test period

- **Average daily gain on test (ADG)** = Weight gained / days on test
- **Daily feed intake (DFI)** = Feed consumed / days on test
- **Feed conversion ratio (FCR)** = Feed consumed / weight gained = DFI / ADG
- Accumulated tissue (fat, protein, ..) → indicator **lean meat content (LMC)**

- Selection traditionally on ADG, FCR and LMC

Achievements: phenotypic trends on station

1977 to 2010: ES, SL, PREMO/ESV, D

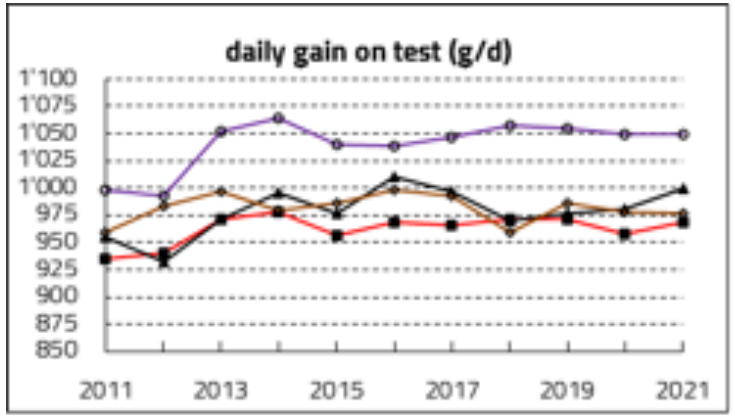
Abb. 18: Entwicklung der Mast- und Schlachtleistung an der MLP (Umstellung Fütterung 1986, 2009).

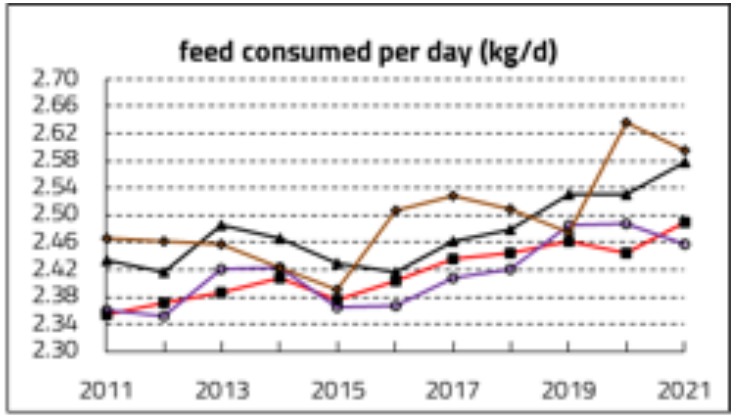
Masttageszunahmen (MTZ)

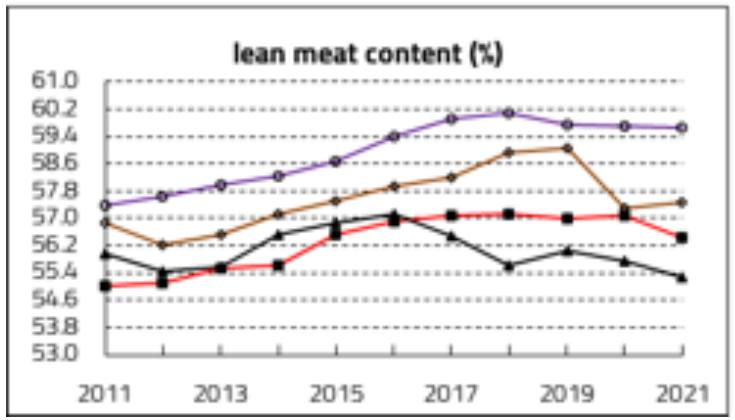
Futterverwertung (FV)

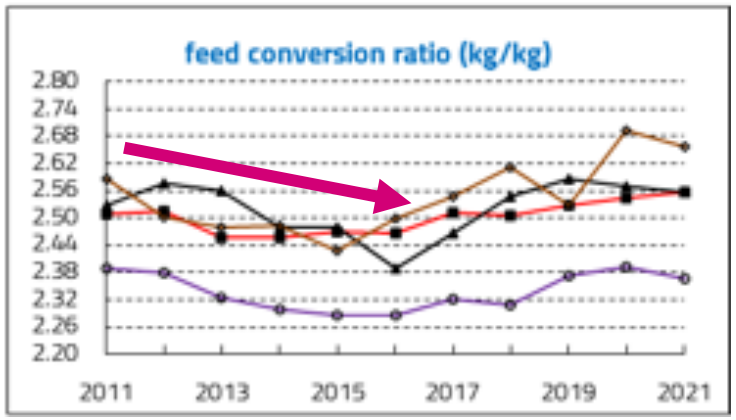
Anteil wertvolle Fleischstücke (AwF)

2011 to 2021: ES, SL, PREMO/ESV, D









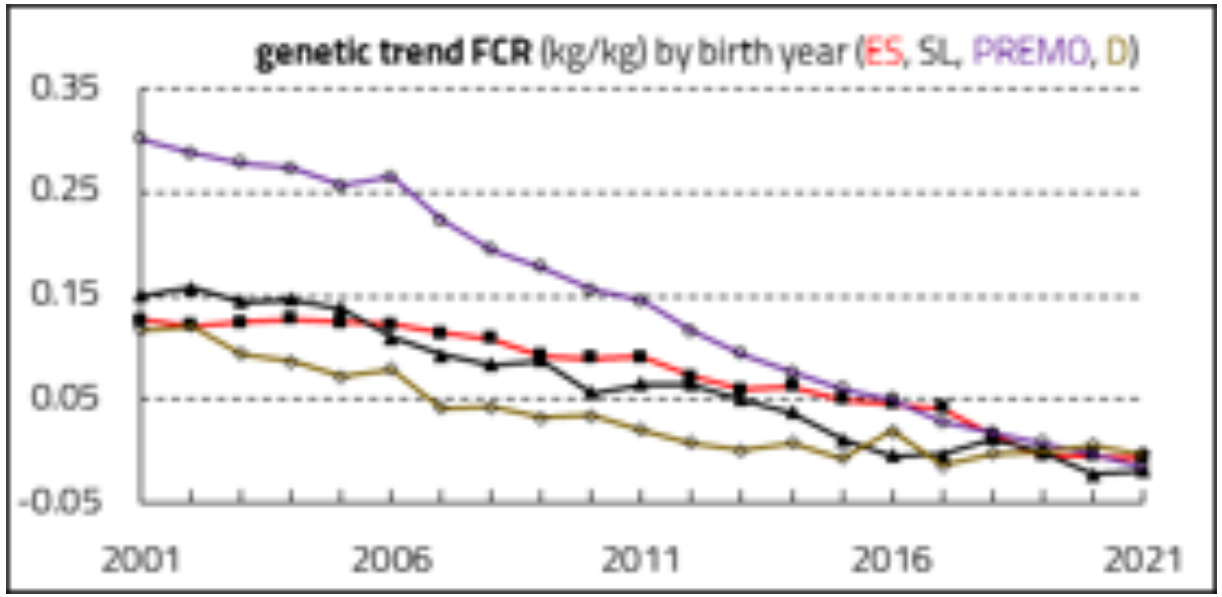
Achievements in feed efficiency

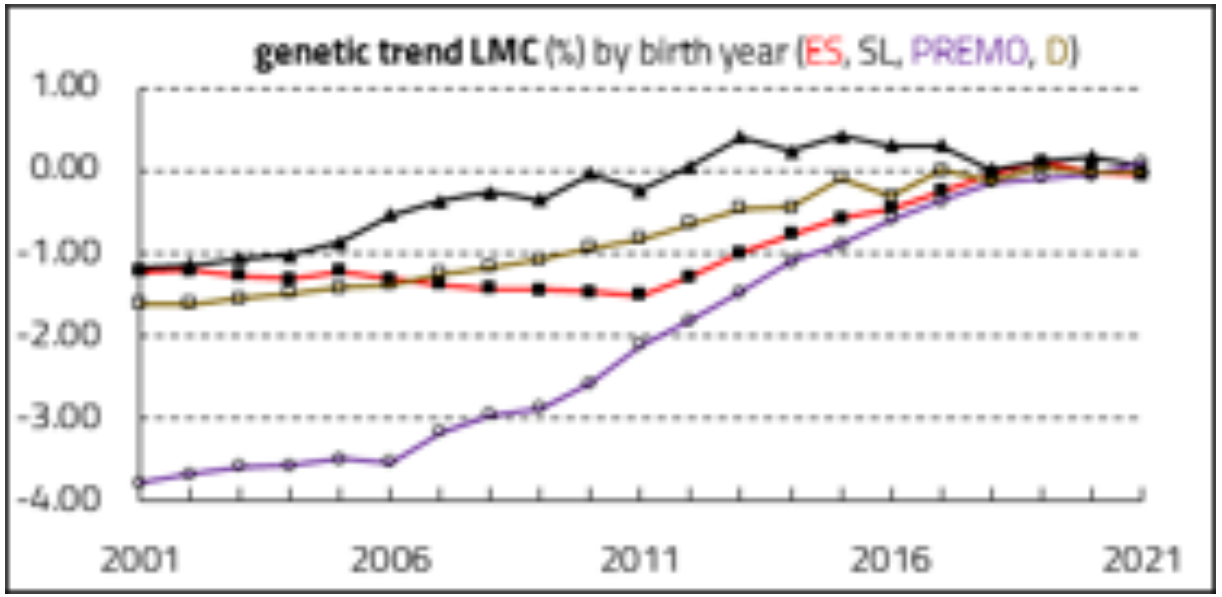
- **On phenotypic level** (rough approximation!) 1977 to 2021
  - 1977: FCR 3.0 (testing 25-100kg, lower energy and lysine content)
    → 240kg feed to grow pig from 30 to 110 kg. Carcass with approx. 57 kg lean meat.
  - 2021: FCR 2.5 (testing 35-110kg, higher energy and lysine content)
    → 200kg feed to grow pig from 30 to 110kg. Carcass with 63kg lean meat.

➢ **40 kg (17%) less feed to produce 6 kg (11%) more lean meat in 40 years.**
(feed has changed over time: higher energy and nutrient density)

Achievements in feed efficiency

- **On genetic level** (estimated as trend of EBVs over birth years)





- -0.2 FCR in 20 years
- + 2.0 LMC in 20 years

➢ **16 kg less feed and 2.2 kg more lean meat in last 20 years.**

Switch from FCR to DFI in the selection goal to avoid selection on ratio trait

- FCR = feed consumed / weight gained = (DFI x days on test) / (end – start weight) =
  = DFI / ADG can be improved by decreasing DFI and/or increasing ADG
  → difficult to direct selection path for DFI and ADG
- Gunsett JAS 1984: selection on index of components is more efficient than on ratio, and selection pressure on the components is defined by the index weights (confirmed by many studies incl. Zetouni et al JAS 2017 on methan / kg milk)
- ADG is also a trait in the selection goal → change in index weight for ADG affects FCR!

- $I_{PROD\mathbf{old}} = w_{ADG} \times EBV_{ADG} + w_{FCR} \times EBV_{FCR} + w_{LMC} \times EBV_{LMC} + ...$
- $I_{PROD\mathbf{new}} = w_{ADG} \times EBV_{ADG} + w_{DFI} \times EBV_{DFI} + w_{LMC} \times EBV_{LMC} + ...$ (since 1.1.2020)

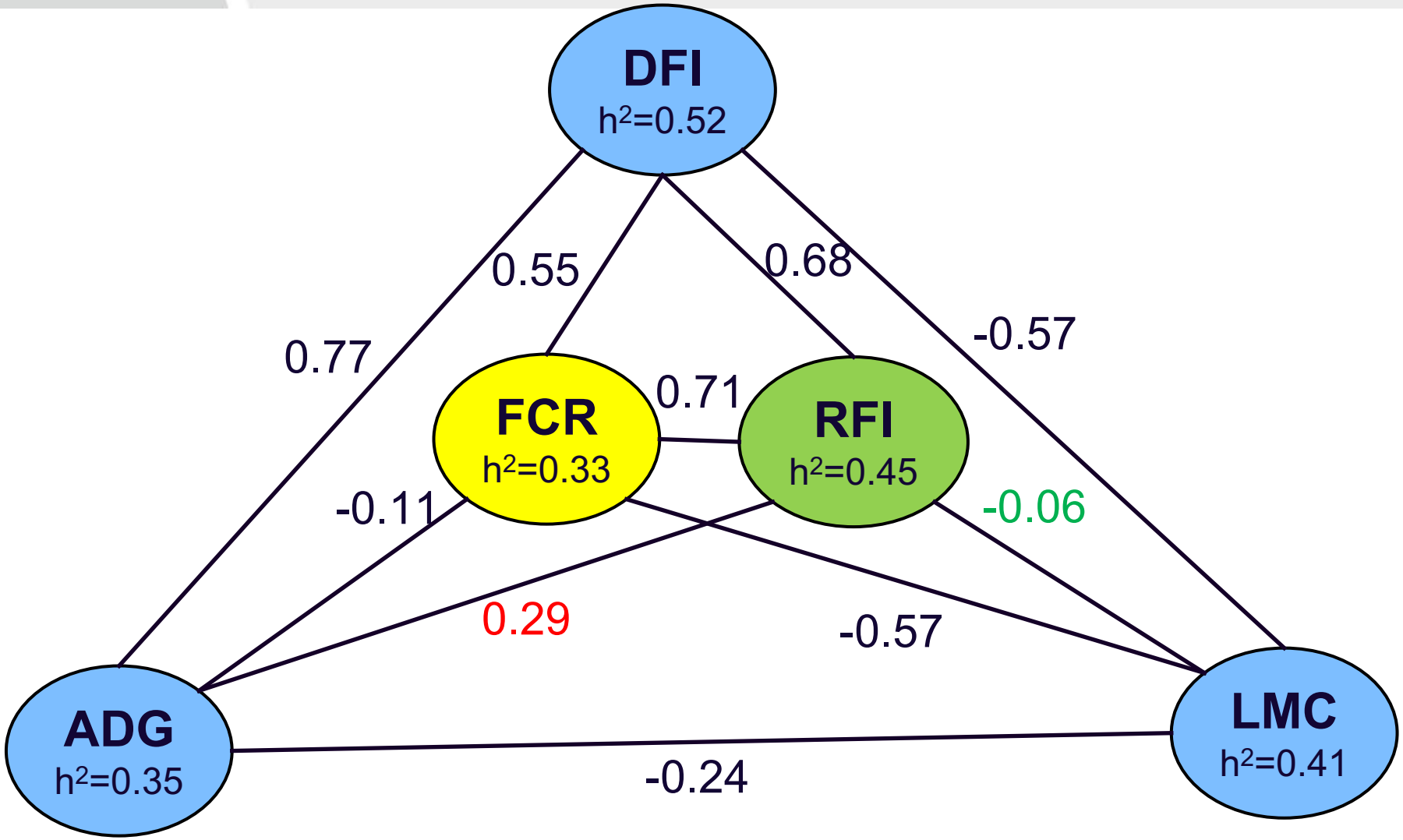
➢ **Now, easier direction of selection path for DFI and ADG for improving feed efficiency**

Residual feed intake (RFI) as an alternative?

- RFI = difference between actual feed intake and that predicted based on the requirements for production and maintenance
- DFI = b_1 x W_{met} + b_2 x ADG + b_3 x LMC + Cont.Grp + Sex + e → e = RFI
  (DFI corrected for ADG and LMC which are also important selection traits)
- Positive RFI = intake is larger than expected in the analyzed population for animal specific metabolic weight and production => inefficient
- RFI also harbors measurement errors in the traits involved or model misspecification.

- RFI = function of DFI, ADG, LMC, ….

Genetic parameters of basic growth traits and derived efficiency traits



basic traits

derived traits

Better to combine the basic traits in a multiple trait evaluation and an index for selection

Nutrient efficiency as an alternative?
N- and P-efficiency (Saintilan et al 2013)

- **N- or P-losses** = Input in feed – accumulated in the carcass
- **N- or P-efficieny** = accumulated / input
- Input = Feed consumed x concentration in the feed
  starter and finisher feed with similar concentrations
  → more or less proportional to feed consumed,i.e. DFI x days on test
  → more or less proportional to FCR
- Accum = function of body weight (and of LMC for N)
  with fixed weights at start and end of test and little variation in LMC
  → more or less constant
- **Genetic correlation with FCR is ± 1**

➢ **no benefit as long as N/P retention can not be measured more accurately**

Agroscope project on N-efficiency

(see contribution by Claudia Kasper for more details and update)

- N in feed consumed and N accumulated in the pig measuerd with high(er) accuracy under research conditions
- N-efficiency as an alternative selection trait
- Genetic correlation to FCR = 0.95 (in a first genetic analysis of the data)
- **Ongoing! For an update see contribution by Claudia**

- **My preliminary conclusion**
  - Not much to be gained over traditional selection traits
  - More research needed to target efficiency of the most important physiological path ways
  - New trait(s) must be measurable with reasonable costs

Outlook

- **What do we feed our pigs in 10-20 years?**
  - Feed stuff with less competition to human food
  - Lower energy and nutrient density?
    → DFI and/or capacity of gastrointestinal tract should increase
  - Role of synthetic AS to compensate low density raw material?
  - Role of food industry byproducts in pig diets?

  ➢ **Political decisions have major impact on pig diet**
- **Importance of G x feed interaction?**
  - Own results with low N and P feed indicates GxE
  - Contradictory results in scientific literature

  ➢ **More research needed**

Conclusions

- Very substantial improvement in feed efficiency over the last 40 years of the Swiss pig breeding program
- So far based on simple selection traits such as ADG, FCR or DFI and LMC
- So far not much to be gained by alternative traits that we and others have evaluated
- More reasearch needed on accurate indicators of efficiency of physiological path ways of muscle and fat tissue growth
- Uncertainty about future pig diets and potential G x E have to be considered