Efficient Cow - Strategies for on-farm collecting of phenotypes for efficiency traits

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Efficient cow: Strategies for on-farm collecting of phenotypes for efficiency traits

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Abstract

Under the condition of limited resources production systems have to adopt their strategies for producing milk and beef. Especially the competition on farmland and the resulting higher prices for concentrated feed causes a higher interest in increasing efficiency.

The Federation of Austrian Cattle Breeders (ZAR) started the project "Efficient Cow" in 2013. The aim of the project is to evaluate the possibilities for genetic improvement of efficiency in cattle breeding under Austrian circumstances. Efficiency is seen as a combination of already existing traits: milk, beef and functional traits and traits aiming at feeding efficiency and health. In the year 2014 a one-year data collection was conducted. Data of approximately 5,400 cows, i.e. 3,100 Fleckvieh (dual purpose Simmental), 1,300 Brown Swiss, 1,000 Holstein, kept on 167 farms were recorded. In addition to routine performance recording, new traits like body weight, body measures (body condition score, chest circumference, ...) and data about feed quality, feed intake and health (lameness score, ketosis milk test, claw health, ...) were collected all year round. Further, 3,000 cows with complete data recording are being genotyped.

The next steps are to estimate genetic parameters for newly defined efficiency traits and genetic correlations to other traits within the total merit index. The main focus is on the evaluation of body weight and feed efficiency. A further project aim is modelling the effect of different milk production systems on greenhouse gas emission based on individual animals under Austrian circumstances. Possibilities to increase efficiency in cattle breeding as well as to reduce emissions indirectly will be analysed.

By collecting this wide range of different information on the project farms, the approach is to find auxiliary traits that are easier and cheaper to measure than the direct traits. Especially automatically collected data from milking and feeding systems could be a new data source for routine phenotypes. But also a structured recording of different management tools like body condition or lameness scoring on a limited number of cows would be a good starting point for further developments of Austrian dairy cattle breeding programs.

Keywords: efficiency, phenotypes, dairy cows, functional traits.

Introduction

In the next decades the world human population will further increase, and therefore the demand for dairy products will expand rapidly. Due to limited agricultural area, dairy production will compete with production of other food and bio-energy. Against this background improving resource efficiency is of increasing international interest. Additionally, because feed costs represent more than 50% of total costs in dairy production, improving of feed efficiency is a viable approach to increase herd profitability (de Haas *et al.,* 2014). Under these conditions of production, a focus has to be put on how to get more milk from each unit of feed rather than on the annual milk yield per cow. In several countries efforts are therefore being made to establish genomic breeding values for feed efficiency. Efficiency is not only described by feed efficiency. Also other aspects as health, good reproduction and longevity are of economic importance. Efficiency needs to consider input and output. Output can be defined in means of progeny, dairy and beef production, but also reduced production costs due to a higher feed efficiency or little losses due to involuntary culling or low health associated costs. A survey among Austrian farmers in 2012 (Steininger *et al.,* 2012) showed their increasing awareness and interest in efficiency and health traits as higher costs for concentrates are expected. The ongoing discussion about greenhouse gas pollution has been another reason that the project "Efficient Cow" was started in Austria. As the facilities to record such data in research herds are limited in Austria, the focus of this project is to explore data from on-farm recording. As the major interest is genetic improvement of these traits a reasonable number of animals needs to be available for the estimation of genetic parameters for newly defined efficiency traits and genetic correlations to other traits within the total merit index. Aspects are to evaluate the context of body weight and feed efficiency or to explore the relationship of efficiency and health. A further project aim is modelling the effect of different milk production systems on greenhouse gas emission based on individual animals under Austrian circumstances. Possibilities to increase efficiency in cattle breeding as well as to reduce emissions by using auxiliary traits will be analysed.

Recording of phenotypes

The Federation of Austrian Cattle Breeders (ZAR) started the project "Efficient Cow" at the end of the year 2012. The aim of the project is to evaluate the possibilities for genetic improvement of efficiency in cattle breeding under Austrian circumstances. Efficiency is seen as a combination of already existing traits: milk, beef and functional traits and traits aiming at feed efficiency and health. In the year 2014 a one-year data collection was conducted. Data of approximately 5,400 cows, i.e. 3,100 Fleckvieh (dual purpose Simmental, 1,300 Brown Swiss, 1,000 Holstein) kept on 167 farms were recorded. In addition to routine performance recording, new traits like body weight, body measures (body condition score, chest circumference, ...) and data about feed quality, feed intake and health (veterinarian diagnoses, lameness score, ketosis milk test, claw health, ...) were collected all year round. In total, 3,000 cows with complete data recording are being genotyped within the project Gene2Farm. The mid-infrared (MIR)-spectra have been standardized and stored as well. The farms were selected in a way that different production circumstances in Austria are covered. This means that included farms cover low input farms located in the very mountainous regions but also intensive farms in climatically favourable regions. The average herd size with 32.6 cows is almost double of the Austrian average.

Efficiency traits

Feed efficiency in lactating cows is a complex trait consisting of and influenced by several parameters. For lactating animals, many feed efficiency definitions exist in the literature (Hurley *et al.,* 2014). Berry and Crowly (2013) describe two types of traits, ratio and residual traits of efficiency. Ratio traits include milk production per unit intake, called feed conversion efficiency (FCE) or milk production per kg body mass or intake per kg body mass. FCE is commonly used to describe feed efficiency, but this definition does not take note of the contribution of mobilisation of body reserves to the energy supply of the animal (Roche *et al.,* 2009). Berry and Crowly (2013) suggest the definition for FCEadj, which includes body tissue change. Also the partial efficiency of milk production (PEMP) is used to express feed efficiency. Therefore the energy corrected output is divided by feed intake after accounting for energy required for maintenance. Currently residual feed intake (RFI) replaces ratio traits for calculating food efficiency. RFI is defined as the difference between energy intake and demand and is usually estimated as the residuals from a least squares regression model regressing feed intake on the various energy sinks. Improving RFI is a costly and complex challenge due to the difficulties to measure the individual animal feed intake. Genomic selection has allowed renewed interest in breeding for feed efficiency, because genomic predictions for DMI and RFI derived from research projects in several countries, where many data are collected from reference animals in experimental herds (Weigel *et al.,* 2014).

Data of this project are collected on farms and there is no possibility for measuring daily individual feed intake in general. From some feeding systems the amount of concentrates fed per animal and day is available. Nevertheless many details of feeding are collected and feed intake is estimated using the evaluation formula of Gruber *et al.*, (2004). Due to a lack of data of on individual feed intake, feed efficiency will be calculated with FCE, FCEadj and PEMP. For calculating these traits the data basis seems to be appropriate, because data of live weight and BCS are collected several times over the entire project duration.

The individual feed intake estimation by the Austrian Agricultural Research and Education Centre Raumberg is scheduled for summer 2015. Therefore only simple efficiency traits, like milk yield by metabolic weight (ECM / weight0.75) can be calculated in the meantime.

Further research topics are to develop parameters to measure production efficiency where also other information concerning beef traits, reproduction, mobilisation and different health aspects are considered.

Observed data

Within the scope of the routine performance recording all dairy cows were weighed, chest circumference and waist circumference were measured as well as body condition score (1 to 5), muscularity (1 to 9) and lameness score (1 to 5) were recorded (Table 1).

Beside these traits also data about feed quality, fodder and health (ketosis milk test, claw health, ...) were collected. On the 7th and 14th day after calving a ketosis milk test was done. Table 2 shows the distribution of results in percent.

Feedback for farmers

For the motivation of the participating farmers a benefit for their farm is important. Therefore an individual feedback based on the data of their farm is in elaboration. A first analysis including density plots for traits collected at every routine performance recording (body weight, BCS, ..) and raw data were provided in August 2014, a midterm report in May 2015 and a final more extensive report is expected in November 2015.

Table 1. Means and standard deviations for weight, waist circumference (WAIST), chest circumference (CHEST), muscularity (MUSC), body condition score (BCS) and lameness score (LAME) by lactation group (LACT) and breed (FL = Fleckvieh / Simmental, BS = Brown Swiss, HF = Holstein Frisian).

	Breed	Cows	N	Lact 1	Lact 2	Lact >=3
Weight	FL	3984	29763	685 (±79)	734 (±83)	776 (±84)
	BS	1605	12788	618 (±77)	665 (±79)	691 (±78)
	HF	1215	8836	624 (±77)	677 (±79)	709 (±76)
Waist	FL	3981	30031	251 (±14)	259 (±14)	265 (±13)
	BS	1604	12497	243 (±14)	251 (±13)	256 (±13)
	HF	1215	8890	249 (±14)	258 (±13)	262 (±13)
Chest	FL	3982	30039	208 (±10)	212 (±10)	217 (±10)
	BS	1604	12498	200 (±9)	205 (±9)	209 (±9)
	HF	1214	8888	207 (±10)	212 (±10)	215 (±10)
Musc (1-9)	FL	3977	29866	5.58 (±1.21)	5.72 (±1.33)	5.89 (±1.4)
	BS	1604	12501	4.75 (±1.3)	4.76 (±1.34)	4.6 (±1.42)
	HF	1215	8897	4.08 (±1.51)	4.13 (±1.56)	4.15 (±1.51)
Bcs (1-5)	FL	3981	30044	3.32 (±0.52)	3.33 (±0.55)	3.37 (±0.62)
	BS	1604	12500	3.21 (±0.46)	3.17 (±0.53)	3.08 (±0.59)
	HF	1215	8903	2.99 (±0.68)	2.93 (±0.67)	2.9 (±0.71)
Lame (1-5)	FL	3981	29768	1.13 (±0.43)	1.2 (±0.52)	1.42 (±0.77)
	BS	1603	12754	1.11 (±0.44)	1.18 (±0.5)	1.36 (±0.73)
	HF	1214	8778	1.18 (±0.5)	1.33 (±0.63)	1.56 (±0.81)

Table 2: Distribution of ketosis milk test results in percent by lactation group (L. 1 – L. ?3) and breed (result groups: <100 µmol/l ... negative (-), 100-200 µmol/l ... weakly positive (~), 200-750 µmol/l ... positive (+), >= 750 ... strongly positive (++).

	Fleckvieh / Simmental			Brown Swiss			Holstein		
	L. 1	L. 2	L. ?3	L. 1	L. 2	L. ?3	L. 1	L. 2	L. ?3
Negative (-)	71.7	69.1	58.1	62.0	50.6	50.4	68.1	58.7	54.6
Weakly positive (~)	23.4	24.0	31.8	30.3	39.0	38.4	25.5	33.8	33.6
Positive (+)	4.9	6.7	9.8	6.1	9.5	9.8	5.7	7.1	9.9
Strongly positive (++)	0.1	0.1	0.3	1.6	0.9	1.4	0.7	0.4	1.9

First results and discussion

As the first efficiency trait energy corrected milk yield by metabolic weight (ECM/ weight0.75) has been calculated. About 45.400 weighings were included in the analysis. The parameter was calculated for each observation by the formula:

$$\text{ECM} / \text{weight}^{0.75} = \frac{(0.38 * \text{fat\%} + 0.24 * \text{protein\%} + 0.816) * \text{milk yield}}{3.14 * \text{weight}0.75}$$

Because the impact of ECM / weight 0.75 is very hard to explain, for comparing the results between animals and herds plots showing only ECM against weight but with trend lines for efficiency were generated. All plotted elements were standardized for lactation day 100 and no pregnancy. In the first step a model for estimating the predicted weight on lactation day 100 was set up. The model for estimating weight includes following effects:

$$weight = lactday + pregday + pregday^2 + lactgroup + calving\ age + farm + farm:cow \quad (1)$$

where lactation day (lactday), day of pregnancy (pregday), lactation group (lactgroup - levels: 1, 2 and ?3) and the age at first calving (calving age) are used as fixed effects. Farm and cow nested within farm (farm:cow) were used as random effect.

In a second step for the three lactation groups separate linear models were set up to derive the relationship between the weights of animals and ECM in this lactation group. These three models were used to plot this relationship. Following effects are included:

$$ECM = weight + weight^2 + lactday + lactday^2 + pregday + calving\ age + fodder +$$

$$+ fodder:farm + fodder:farm:cow \quad (2)$$

where ECM is the observed energy corrected milk and weight, lactation day (lactday), day of pregnancy (pregday) and fodder (levels: with or without silage maize in the diet) are fixed effects. As nested random effects fodder:farm and fodder:farm:cow are used.

For each cow the estimated random effects for ECM and weight were added to the expected value of a standard cow in this lactation group on lactation day 100 and no pregnancy. Figure 1 and 2 are showing for two example farms these generated values together with the fitted curves of model 2. For comparison between farms similar plots were also generated with the mean values of farms within a specific district or group of related farms.

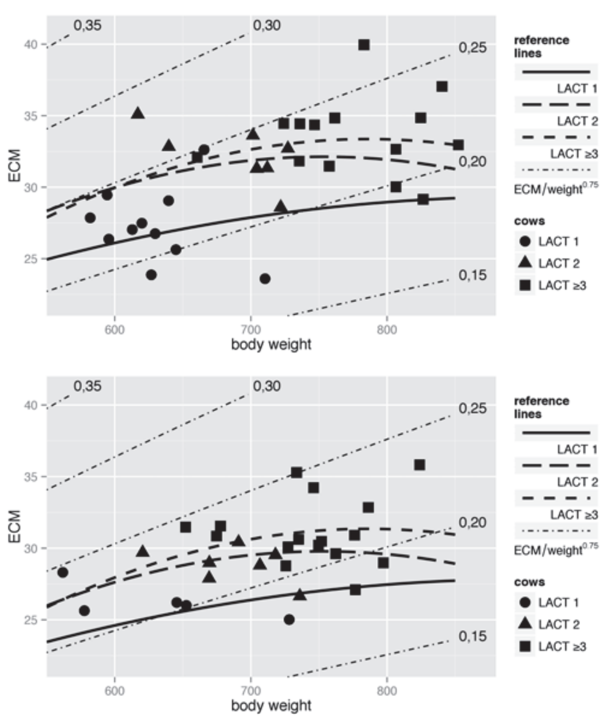

Figure 1 and 2. Estimated random effects for ECM and body weight of all cows from two farms and reference curves for the three lactation groups considering the fodder group of the farm.

All analysis was done for each breed separately. So no breed effect was taken into account in any of the models used.

Conclusions

The extensive recording of novel phenotypes from about 5,300 cows under on-farm-conditions has been a big challenge. Recording of body weight was easier to handle than taking different body measures which were intended as auxiliary traits for body weight. Positive feedback was given regarding recording of management tools like lameness or body condition scoring. The biggest difficulty is to record the feeding information per individual across the different feeding systems and ration compositions on-farm. The amount of concentrates can be recorded more or less accurately when concentrates are distributed by automation. If total mixed ration (TMR) or partial mixed rations (PMR) is fed, no detailed information about the amount of concentrates eaten is however available per animal. The quality of the feed stuff was analysed continuously and a formula to calculate the feed intake (Gruber *et al*., 2004) is used. Comparison with data from station may help to estimate the bias associated with this calculation. The advantage of this on-farm-trial is the availability of data from a large number of animals. The genetic parameters will give insight into the value of auxiliary traits describing efficiency. For the ongoing discussion concerning genotyping of cows with extensive recording of phenotypes the expected results might help to define reliable, repeatable traits that can be recorded with limited amount of work. The experience shows that the more data can be used from automation the better it is. The limitation of these data is quite often the standardization and the availability of interfaces for data exchange.

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