LowInputBreeds

Issue 10 August 2014

NEWSLETTER of the LowInputBreeds project

Development of integrated livestock breeding and management strategies to improve animal health, product quality and performance in European organic and 'low input' milk, meat and egg production

Editorial

Dear Readers,

Sadly our project has come to an end. The volume and quality of work carried out by everybody involved over the 5 years is impressive to say the least - possibly overwhelming with respect to reporting everything to the EU, which was a positive challenge although this comment comes hotly behind an intensive period of report writing.

The last 6 months have been very eventful with more technical notes being completed, our 4th and final Symposium held in April 2014 at Newcastle University, UK, and then, in July (slightly behind our official submission date), the 4th periodic report, all outputs and the final report from LowInputBreeds were all lodged onto the EU's reporting system – no mean feat!

This Newsletter includes an executive summary of project outputs (page 2) (5 years' work by all of us distilled down to 4000 characters), abstracts of papers presented at the symposium, along with authors' contact information if more details are sought (page 4) and finally mention of our additional technical notes, accessible from our web site (page 23).

Our sincere thanks go everybody involved in the project, whether as active contributor to the research, its administration and dissemination or simply readers of our Newsletter.

Funding may have ceased for LowInputBreeds and we are signing off as co-ordinators but more findings are in the pipeline; there are still papers to prepare and the website (www.lowinputbreeds.org) will continue. We advise readers to log into at the site regularly for publication updates.

Veronika Maurer, scientific coordinator and

Gillian Butler, coordinator

Contents

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The LowInputBreeds project: summary of results

The LowInputBreeds project integrated breeding and management to improve animal health, product quality and performance in organic and low input milk, meat and eggs. Four technical sub-projects (SP) were evaluated for ethical, economic and environmental impact in a 5th subproject, which also covered training and dissemination, including our website which lists contacts and bi-annual newsletters.

Subproject 1 on cattle[1] estimated genomic breeding values with reasonable accuracy for novel functional traits, in 1500 Brown Swiss (BS) cows on low input and organic farms in Switzerland. US BS genetics significantly influenced milk fatty acid composition. Gene analysis shows no major differences between these Brown Swiss cows and those on high-input farms or reference German Holstein Friesians. In the UK yields, milk quality, health and welfare was assessed for 1000 crossbred dairy cows on low-input/organic farms and preliminary analysis reveals differences between farms and within population on the same management. Simulation studies assessed the impact of natural service bulls on genetic gain and inbreeding in organic genomic breeding programs, revealing superiority in the use of genomics for AI bull selection.

The sheep subproject[2] focused on mountainous and Mediterranean areas; assessing genetic, nutritional and grazing management on a) stress resistance in robust sheep, b) integrative approaches to control intestinal nematodes, and c) meat and lamb carcasses quality. The role of genetics was evaluated within Greek Sfakiano dairy sheep for resistance to heat, parasites and mastitis - investigating scope for marker genes. Elsewhere, rustic and intensive breeds were compared for parasite resistance, carcase and meat quality, as well as the potential to exploit bioactive, tannin-rich forages and. Citrus pulp diets reduced subsequent meat lipid oxidation, changes to grazing management reduced parasite infection (e.g. transhumance practices) and improved lambs carcase and fat composition (timing of grazing and/or fertiliser application). A few long-term studies showed potential integration of 2 or 3 factors (genetic, nutritional and/or grazing management) to control parasites or lamb quality.

Subproject 3[3] **focused on pigs**, identifying breeds suited to low input systems; designing dedicated breeding systems, investigating heat tolerance, reduced piglet mortality and improved meat quality by breed choice and management. Conventional

[1] The work packages of subproject 1 on dairy and beef cattle production systems:

Work package 1.1 Development of within breed selection systems to improve animal health, product quality and performance traits; comparing genome-wide and traditional quantitative-genetic selection

Work package 1.2 Development of improved cross breeding strategies to optimise the balance between 'robustness' and performance traits; comparing cross-breeds with pure-bred Holstein Friesian genotypes

Work package 1.3 Design of optimised breeding and management systems for different macro-climatic regions of Europe; model-based multi-criteria evaluation with respect to performance, animal health and welfare, product quality and environmental impact

[2] The work packages of subproject 2 on sheep production systems:

Work package 2.1 Development of within breed selection systems to improve abiotic and biotic stress resistance and performance traits; comparing marker assisted and traditional quantitative-genetic selection systems for functional traits.

Work package 2.2 Development of improved endoparasite management strategies based on integrating (a) feed supplementation with tanniniferous forages with (b) strategic use of clean pastures and/or (c) the use of parasite tolerant breeds.

Work package 2.3 Development of strategies to improve lamb meat quality based on optimising (a) TF feed supplements (b) grazing regimes and/or (c) the use of stress tolerant breeds

[3] The work packages of subproject 3 on pig production systems:

Work package 3.1 Development of a flower breeding system to improve pig survival and robustness related traits in small populations; comparing the performance of breeds from 'flower' and conventional breeding systems.

Work package 3.2 Effect of management innovations (gilt rearing and lactation systems) on mothering ability of sows as well as pre- and post-weaning diarrhoea and losses of piglets.

Work package 3.3 Effect of traditional, improved and standard hybrid pig genotypes and feeding regimes on carcass, meat and fat quality in heavy pigs used for premium, regional pork products.

breeds suited commodity organic pork production, as did prolific, leaner traditional breeds, especially if crossed with conventional white boar breeds to give leaner carcasses. Rotational breeding proved a viable structure for Dutch organic pigs, especially with AI boars ranked to an organic selection index. Genetic analyses shows breeding for heat tolerance is possible due to variation in existing lines. The effect of dam genetics and rearing on piglet mortality was assessed in both conventional and organic environments with genotype*environment interactions detected. Conventionally reared sows selected for low mortality had less piglet mortality compared with those of lower genetic merit but the opposite was found for organic sows. Saddlebacks under organic conditions produced quality, dry fermented sausage in contrast to fast growing modern hybrids, however, if the price is not adapted to carcase or processing quality, Saddlebacks may not be economic.

The **subproject on laying hens**[1] in free range and organic production a) developed a participatory system to optimise and test genotypes, b) optimized management for diet and feather pecking, c) extended productive life and d) assessed egg quality. Basic inputs came from farmers in France, Switzerland and The Netherlands with observations and discussions in CH and NL. Most farms benchmarked production using (on line) programs, giving a practical system to test genotypes across farms. They tend to have a long-term relationship with egg traders (CH) or rearing companies (NL); both being influential in breed choice. Brown egg strains dominated although the proportion of White Leghorns did rise. Management of organic and free-range flocks are improving with better-suited genotypes, closing the production gap on barn and cage production. Modelling suggests heavier hens might be more profitable than existing genotypes, except in organic systems with high feed costs. Protein quality is a challenge in organic diets, hindered by the EU ban on meat and bone or insect meal hence plant proteins were evaluated to replace imported soya.

By developing and integrating (a) genotypes selected for performance, robustness and product quality traits, and (b) management innovations to improve 'low input' systems the project made a significant contribution towards regionally-adapted breeding strategies, compatible with sustainable production, high product quality and organic principles.

More information

www.lowinputbreeds.org

[1] The work packages of subproject 4 on laying hen production systems:

Work package 4.1 Development of 'farmer participatory' breeding systems to improve productivity, health and welfare and egg quality related traits; comparing standard with farmer participatory breeding systems

Work package 4.2 Effect of, and interactions between, laying hen genotypes, feeding regimes, 'welfare-friendly' moulting protocols and prolonged use of layers on performance, and animal health and welfare

Work package 4.3 Effect of, and interaction between, laying hen genotypes and management innovations on egg quality

Proceedings of the fourth symposium of the LowInputBreeds project

The fourth symposium of the LowInputBreeds project (www.lowinputbreeds.org) took place at Newcastle University in Newcastle, UK, on April 15 and 16, 2014. At this symposium, the results of the LowInputBreeds project, which came to an end in April 2014, were presented.

Programme of the Final LowInputBreeds Symposium – 15th & 16th April 20014, Newcastle University, UK

Tuesday 15th April

- 08.45 - Registration - Herschel Building, Newcastle University
- 09.00 – Meeting commences (Lecture Theatre 2, Herschel Building)

Cattle (Tuesday am)

- An overview SP 1:
  Anna Bieber (FiBL) on behalf of Henner Simianer (Georg-August-University Göttingen)
- Interaction of production, fertility and fitness, and methane emission in low input cattle production
  Christian Reimer (Georg-August-University Göttingen)on behalf of Tong Yin and Sven König (Kassel University)
- Functional traits and genomic prediction
  Christian Reimer (Georg-August-University Göttingen)
- Cross- bred dairy production in UK
  Gillian Butler (Newcastle University)
- Industrial partner's benefits from the LowInputBreeds project:
  Fritz Schmitz-Hsu (Swissgenetics)

Sheep (Tuesday am)

- An overview SP2
  Hervé Hoste (INRA)
- Effects of tannin containing resources on the parasitic nematodes
  Hervé Hoste (INRA) and/or Smaro Sotiraki (Demeter)
- Lamb meat quality
  Alessandro Priolo (University of Catania)
- Epidemiology of gastrointestinal parasites and milk quality in ewes
  Nikos Voutzourakis (Newcastle University)
- Integrated strategies to control of gastrointestinal parasites
  Steffen Werne (FiBL)
- Use of Legumes and quality of lamb meat
  Sophie Prache / Thais Devincenzi (INRA Theix)
- A Commercial Perspectives on dissemination to farmers
  Smaro Sotiraki (HAO / DEMETER)
- 13.00 – LUNCH – Common Room, Agriculture Building, Newcastle University
- 14.00 – Meeting recommences (Lecture Theatre 2, Herschel Building)

Pigs (Tuesday pm)

- An overview of SP 3
  Jascha Leenhouwers (Topigs)
- Effect of heat stress and phosphorus supplementation on pig electron chain gene expression
  Simone Guimarães (Federal University of Viçosa, Brazil)
- Meat quality: survey approach
  Diane Holmes (Newcastle University)
- Commercial perspective of involvement in the LowInputBreeds project
  Jascha Leenhouwers (Topigs)

Poultry (Tuesday pm)

- An overview of SP4
  Ferry Leenstra (Wageningen UR Livestock Research)
- Findings from the farm visit
  Monique Bestman (Louis Bolk Institute)
- Fatty acids in eggs: the impact of season, management and genotype
  Eleni Chatzidimitriou (Newcastle University)
- Moulting to extend lay period
  Veronika Maurer (FiBL)
- Commercial perspective on involvement in the LowInputBreeds project
  Jeroen Visscher (Institut de Sélection Animale BV)

Wednesday, 16th April

- 09.00 – Meeting commences (Lecture Theatre 2, Herschel Building)

Ethical issues

- Ethical issues considered in the LowInputBreeds project
  Karsten Klint Jensen (University of Copenhagen)
- Anna Bieber
- Hervé Hoste
- Jascha Leenhouvers
- Ferry Leenstra

LowInputBreeds Subproject 1

Overview of subproject 1: Improving performance, animal health & welfare, environmental impact and product quality in organic and "low input" dairy cow production systems

A. Bieber[1] and H. Simianer[2]

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Subproject 1 of the LowInputBreeds project focused on dairy cattle breeding. Approximately 1500 Brown Swiss dairy cows from 40 low input and organic farms in Switzerland were phenotyped for a set of new functional traits during six farm visits. For results on the subsequent parameter estimation for these traits (Kramer et al., 2013 a+b) as well as the results from studies on accuracy of genomic breeding values estimated for them (Kramer et al., 2014) see summary of C. Reimer in this document (page 7). The impact of US Brown Swiss genetics on milk quality from low input herds in Switzerland and the interactions with grazing intake and pasture type was also studied (Stergiadis et al., unpublished). Furthermore, analysis of the haplotype inventory revealed no major differences between the haplotype and linkage disequilibrium characteristics of the low input Brown Swiss sample and the high input Brown Swiss populations and the German Holstein Friesian population used as reference (Qanbari et al., 2011). For preliminary results with regard to the effect of different cross-breeding strategies on milk quality, animal health and welfare see summary from G. Butler. Detailed results from simulation studies assessing the impact of natural service bulls on genetic gain and inbreeding in organic dairy cattle genomic breeding programs (Yin et al., 2014) were presented by C. Reimer (see summary page 7). The adaptation of simulation models in a wider range of macro-climatic zones is still ongoing.

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Genetic analysis of Brown Swiss cows from low input farms in Switzerland

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Production, fertility, and conformation records from Brown Swiss cows kept in low input farms in Switzerland were used in this study. (1) Fertility traits from 1283 cows were analysed with random regression models (RRM) with parity as a time covariate. Generally, low heritabilities were found for these traits. (2) A simulation study was applied to compare genetic gain between natural service sires (NSS) and artificial insemination sires (AIS) in organic dairy cattle breeding programs. Selecting

genotyped NSS from organic herds is competitive with selecting AIS based on estimated breeding value in conventional farms. (3) Production, fertility, and conformation records were available from 961 cows. Test-day methane emissions (ME) were predicted based on two deterministic equations (ME1, ME2), stochastic simulations, and production and conformation traits. Bivariate RRM were applied for all combinations of ME and production traits. For estimating genetic correlations between ME and fertility traits, RRM were used for ME, but animal models were applied to fertility traits. Predicted ME had moderate heritabilities of 0.15 to 0.37. Genetic correlations between ME2 and milk yield ranged between 0.70 and 0.92. Genetic correlations between ME with days open and with calving interval increased across lactation (0.10 to 0.90). Positive correlations of 0.02 to 0.49 were found for ME2 and clinical mastitis.

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Novel functional traits in low input dairy cattle: Genetic characterisation and the potential of genomic selection

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Phenotypic data of Brown Swiss cows collected from 40 Swiss dairy farms within the EU-funded project LowInputBreeds were used to evaluate the possibilities of breeding for alternative traits. (1) Estimation of genetic parameters for novel functional traits such as general temperament, milking temperament, aggressiveness rank order in herd, milking speed, udder depth, position of labia and days to first heat revealed low to moderate (milking temperament: 0.04; Udder depth: 0.42) heritabilities. (2) The per udder quarter measurement of milk composites revealed that fat and protein content where enriched in the front quarter, whereas lactose was enriched in the rear quarters, but variability of these contents among udder quarters, considered to be an interesting trait, has nearly no heritability. (3) Genomic selection appears feasible even though a relatively small number of animals were used. Medians of accuracies for the traits from (1) ranged between 0.64 and 0.74. (4) Eventually a comparison with genomic selection in Holstein-Friesian cows showed, that a 20k SNP chip seems to be sufficient for Brown Swiss, but not for HF. An advanced formula to estimate the accuracy of genomic prediction was presented.

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Crossbreeding for UK dairy production

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In recent years UK dairying has tended to diverge from intensive production, with high levels of supplementation, limited access to pasture and milking 3 time per day as one extreme and extensive, low-input systems relying heavily on grazing with little concentrate feed at the other end of the scale and a range of intensities in-between. Whereas high yielding Holstein cows are ideally suited to intensive production, they are totally inappropriate for low-input systems. To fully exploit grazing, such herds need to block calve to ensure

peak nutritional requirements coincide with herbage growth, allowing production, fertility and health to be sustained.

As with low-input dairying in New Zealand, UK farms choose cross breeding to find cows suited to milking from grazing, although there has been limited investigation into appropriate breed combinations for differing locations or intensities, or how such crosses can be maintained in a closed herd – hence this study under LowInputBreeds. Management records and milk samples were collected from low-input (n=10) and organic (n=7) herds on 4 occasions through 2011-2012 to compare production, fertility, health and milk quality of 1069 individual cross-bred cows, with various combinations of genes. Results have still to be fully analysed but initial findings were presented at this meeting. The most common breeds represented in monitored cows were Jersey (17%), Swedish or Norwegian Red (17%), Holstein (15%, since many farms were crossing from higher input herds), and NZ Friesian (14%). There were also Holstein/Friesian (10%), Friesian of unknown origin (7%), Dairy Shorthorn (7%), Ayrshire (6%), British Friesian (4%), Montbelliarde (2%) crosses and a few cows with MRI and Brown Swiss genes. If we consider the breed contribution to individual cows, Jersey genes ranged from pure bred cows to others with 12.5% Jersey genes (1 of their great-great-grandparents) with the same pattern for NZ Friesian, Dairy Shorthorn, Ayrshire and British Friesian. The contribution of Holstein genes ranged from pure bred cows to 3% and other breeds fell between these extremes.

It is well known that milk yield and composition are greatly influenced by dairy diets although an initial look at this data set (4280 records) reveals variation in milk yield, fat content and fatty acid profiles within herds at the same sampling date. This suggests a considerable genetic influence, assuming cows have access to the same feed resources.

Benefits and conclusions for the Swiss cattle breeding industry

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Braunvieh Schweiz (formerly called Swiss Brown Cattle Breeders' Federation, SBZV) and Swissgenetics got involved in the project LowInputBreeds, when genomic selection (GS) became a hot topic in cattle breeding in 2007. In theory - not proven at that time yet - GS is a promising tool to improve not only performance traits, but also functional ones. In Switzerland, quite many farms are producing according to organic standards, and low input systems are in general widely spread.

Of the results of we learned among other points:

- GS really can help to evolve novel traits, but the success depends on the trait complex; more promising results were achieved with conformation traits than with fertility traits. This can be explained by the lower heritability of fertility traits.
- A good phenotype recording scheme is essential.
- Which new traits are taken now into routine evaluation depends mostly on their economic importance and genetic correlations to existing traits.
- Only recording on a subpopulation and genotyping only cows is feasible, but 1000 cows are not enough for traits with low heritability. The cow subpopulation must be selected carefully depending on the population structure and the relationship.
- GS can be applied to natural service systems.
- The genomic relationship matrix G is much more informative than the traditional relationship matrix A, hence giving a better tool for inbreeding control and for maintaining genetic diversity.

Out of the LowInputBreeds project, we got a considerable number of Braunvieh cattle (mainly cows) genotyped with a high-density SNP panel. Although this increased the reference data set, reliability of routine genomic breeding values did not increase substantially. But the high-density genotypes, mainly the ones from cows, increase the accuracy in the routine imputation procedure. In the context of the LowInputBreeds project, we learned to handle high-density genotypes, how to implement novel functional traits using GS. A major benefit resulted also from the collaboration with the project partners: Valuable knowledge and new ideas could be exchanged. As a conclusion, the Swiss cattle breeding industry can profit out of the LowInputBreeds project manifold, mainly due to the gain of knowledge and experiences.

LowInputBreeds Subproject 2

The sheep subproject of the LowInputBreeds project: An overview of the main studies and results

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Within the Low Input Breed project, the "Sheep sub project" focused on ovine production in mountainous and Mediterranean conditions. Overall the project aims at examining how the combination of genetic, nutritional and grazing management approaches can be exploited in low input systems of production in regard to main objectives:

1. to examine the resistance of rustic (robust) sheep lines and/or breeds to abiotic and biotic stress factors,
2. to assess the effects of integrative approaches to control/prevent gastro intestinal nematodes (GIN) infections in a range of epidemiological conditions, and
3. to examine the effect of low input modes of management on the quality of meat and lamb carcasses.

The role of genetic factors has been particularly evaluated within one Greek breed (Sfakiano sheep) of dairy sheep in regard of resistance to heat and main diseases (GINs and mastitis). The possible use of genetic markers in this context has also been examined. In addition, comparative studies between rustic vs more intensive breeds in regard of resistance to GINs and quality of carcasses and meat have also been performed in other countries underlining the participation of genetic components for these performances.

Studies on nutritional factors have concerned the potential when exploiting bioactive, tannin-containing forages and resources (carob, faba bean) to contribute in the control of GINs in both Mediterranean and mountainous conditions but also the effects of these feeds on the quality of lamb meat, through the modulation of oxidative processes. Similarly, some specific studies have also documented the possible use of citrus pulp to reduce lipid oxidation.

The interest of adapted methods of grazing management has been underlined not only to help in the prevention of GIN infection (e.g. transhumance practices) but also in the quality of lambs carcasses and fat composition (role of the time of grazing and/ or mode of production (low input vs high use of fertilizer)).

Last, a few long term studies have been performed to examine the consequences of integrative approaches combining 2 or 3 factors (genetic, nutritional or grazing management) and the occurrence of possible interactions in the control of GINs or quality of lamb meat.

Summarised results of controlled studies on the anthelmintic effects of tannin-rich forages and crops against gastro intestinal nematodes

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The general objective was to provide information to better exploit tanniniferous resources to control Gastrointestinal nematodes (GINs) in sheep breeding in Mediterranean and Mountainous conditions. The specific objectives aimed at addressing 3 main questions:

Which resources to use? Two tannin containing (TC) forages, sainfoin (*Onobrychis viciifolia*) and/or sulla (*Hedysarum coronarium),* and two crops Carob pods (*Cerotonia silliquum*) and/or faba bean (*Vicia faba*) were initially planned to be used. Because of severe climatic conditions (drought) influencing its growth, the possibility to include sulla in the experiments were withdrawn and there was also a

threat for sainfoin in some locations (Greece). Overall, the results have confirmed the potential effects of different TC resources to disturb the biology of GINs and thus influence the dynamics of GIN populations. However they also suggest variability in results whatever the nature of the TC resource used [(forage (sainfoin) or crops (faba bean and/or Carob pods)].

Origin of the variability in the AH effects? Based on multiple *in vitro* studies using sainfoin as a model, several factors have been identified to affect the variability in the AH activity namely

1. Genetic factors (cultivars of the plant);
2. Environmental factors (phenological stages, sites of production, numbers of cuts) which can be summarized by "stress factors" to the plant;
3. Technological processes (drying, ensiling, pelleting) because of physical factors (pH, temperature, pressure) affecting the quantity/quality of tannins and thus the bioactivity.

How much is needed in the sheep diet to observe a disturbing effect on the biology of GIN populations? Answers to this question first depend on the mode of measurement of tannins in the sheep diet. Whatever the method of measurement used, results of different in vivo studies suggest that a threshold of condensed tannins in the diet has to be reached before observing any AH effect.

Results relying on the same biochemical methods (Folin Ciocalteu), suggest that a threshold from 2 to 3 % of CTs in the diet is requested before obtaining any AH effect. In addition, the nature/quality of tannins (size of polymers; nature of the basic polymers) is also a second key modulating factor to consider

Overall, these data based on the results obtained by three main institutions participating in the LowInputBreeds project, which operated under different climatic/agronomical conditions for the availability of TC resources and for the epidemiology of GIN parasites have shown/confirmed that

- TC resources are active to affect the biology of GINs, but that these AH effects never reached 100% efficacy, whatever is target key stages;
- A variability in results is observed because of a range of genetic, environmental and technological factors.

Such variability can affect the availability of locally grown resources when needed

Therefore, to promote the implementation of TR resources in sheep breeding to control GINs, there is

- a strong need to use standardized resources as much as possible and
- to develop methods to better characterize the resources to use.

Gastrointestinal parasites, subclinical mastitis & milk quantity/quality in ewes in low input Mediterranean dairy husbandry systems

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The aim of our studies was to monitor the performance (milk quality and quantity) and robustness of a Mediterranean mountainous dairy breed (Sfakion breed located in Crete, Greece) under various biotic (i.e. subclinical mastitis and endoparasites infection) and abiotic (i.e. management and environmental conditions) stress factors. For this, over a period of 2 years (2009-2011) we monitored 10 extensive and 10 semi-intensive sheep flocks (enrolling 40 ewes per farm).

In monthly intervals during the course of the study, in a flock level we recorded via a questionnaire management data and collected bulk milk samples. In an individual animal level, same intervals, we collected milk (separate per teat) and faecal samples. Moreover blood samples were collected once from all animals for genetic characterization.

Faecal samples were processed with modified McMaster technique, while for milk samples chemical composition was assessed by infrared methods (Milkoscan™ FT, FOSS) and by flow cell cytometry Colony Forming Units(CFU/ BactoScan™ FC, FOSS) and Somatic Cell Counts(SCC/ Fossomatic™ FC, FOSS). Fatty Acid (FA) profile was assessed by gas chromatography. Samples with SCC above 500,000 were cultured for mastitis-related pathogens. For blood samples single nucleotide polymorphism (SNP) variation in ADRB3 and DQA2 genes was also examined. Significant effects of lambing period, management system and season on both biotic stress factors were identified; spring lambing animals were less affected by subclinical

mastitis and more affected by gastrointestinal parasites. More over lambing period, management system and season had also significant effects on milk quantity and quality; the extensive flocks show a more desired milk FA profile, while the semi-intensive flocks had a more constant milk chemical composition and Fatty Acid profile during lactation period.

The preliminary results regarding genetic characterization (for the 2 genes examined) showed extensive polymorphism variation indicating a strong potential for applying genetic selection approaches. Further research is needed to pursue this goal.

Integrated control of gastrointestinal sheep nematodes

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Due to the increase of nematodes resistant to anthelmintic treatments, alternative control options are required. Several alternative approaches are known for their effect on gastrointestinal nematodes (GIN). Integrated approaches aim for additive or synergic effects for a sustainable GIN control induced by the combination of two or more alternative control approaches. In a first study the effectiveness of the combination of two tannin containing feeds was assessed. Sainfoin (*Onobrychis viciifolia*) and faba bean (*Vicia faba*) was fed as single diet or in combination to periparturient ewes for a period of 25 days. The faecal egg count (FEC) of these animals was repeatedly assessed during the trial. Compared to the control group (ryegrass-clover), the sainfoin fed animals showed a 54.7% reduced FEC ($p < 0.001$). The combined tannin group (sainfoin and faba bean) showed a 40% reduced FEC ($p < 0.001$) compared to the control group. However, there was no difference between the single sainfoin and the combined tannin group. Therefore no additive or synergic effects could be shown by the combination of the tannin feeds. In a second trial, the integrated control approach was the use of a less susceptible sheep breed (Red Engadine Sheep) compared to a high performing breed (Swiss White Alpine) and a forage rich in condensed tannins (sainfoin). Two studies were conducted, one to test the effect of a reduced sainfoin percentage on the FEC and another to test the effect of a 100% sainfoin diet on the nematode numbers of the experimental sheep. It could be shown that a proportion of 55% sainfoin in the diet reduced the FEC of these animals significantly compared to control. It was also revealed that a 100% sainfoin diet can reduce the numbers of *Teladorsagia spp.* ($p = 0.049$) and *Nematodirus spp*. ($p < 0.001$) compared to the control group. Irrespective of sainfoin feeding, the Red Engadine Sheep harboured lower numbers of *Haemonchus spp.* ($p = 0.035$) and *Trichostrongylus spp*. ($p = 0.003$) compared to the Swiss White Alpine. As the effect of breed and sainfoin was not combined in one nematode genus, we consider the effects as non-additive. The considerable effects of the sainfoin feeding and the Red Engadine Sheep, however, suggest the use of either strategy for an alternative GIN control.

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Sensory quality and authentication of lamb meat produced from legume-rich forages

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As low-input and organic farming livestock systems embody features that consumers value, the ability to authenticate meat from these systems has become an important challenge. The presence of forage legumes in these systems is of major importance, because these plants improve pasture quality and reduce dependency on external inputs. However, the

occurrence of off-flavours in the meat has been shown to increase in lambs grazing legume-rich pastures and to be related to the presence of skatole, which is an aromatic compound produced in rumen. This study investigated the dose-dependent response to dietary alfalfa levels of stable nitrogen isotope ratio in lamb meat and of fat skatole concentration and chop flavour and odour, and the ability of nitrogen isotope signature of the meat to authenticate meat produced from legume-rich diets.

Four groups of 9 male Romane lambs grazing a cocksfoot pasture were supplemented with fresh alfalfa forage to obtain four dietary proportions of alfalfa (0%, 25%, 50% and 75%, groups U, L, M and H) for at least 2 months before slaughter.

Perirenal fat skatole concentration was higher for lambs that consumed alfalfa than for those that consumed only cocksfoot, and it increased as soon as the dietary proportion of alfalfa reached 25%. The intensity of 'animal' odour in the lean part of the chop and of 'animal' flavour in both the lean and fat parts of the chop were increased from the lowest level of alfalfa supplementation onwards and did not increase further with increasing levels of alfalfa supplementation. The outcome of this study suggests that these sensory attributes may reach a plateau when perirenal fat skatole concentration is in the range 0.16-0.24 µg/g fat. The nitrogen isotope signature of the *longissimus thoracis et lumborum* muscle discriminated all the U lambs from the H lambs, and gave a correct classification score of 85.3% comparing lambs that ate alfalfa with those that did not. These results are of interest for the authentication of meat produced in low-input and organic production systems, in which leguminous plants are more widespread.

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Farmer participatory studies in dairy sheep in Greece; how we worked with the farmers

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Field studies enable us to study and correlate factors in real life conditions and obtain realistic conclusions. The approach we followed during the LowInputBreeds project to communicate with the famers was based on the following rules:

"Motivation to change"

Basic marketing theory says that a change of practice by a "target" is usually motivated by having to satisfy a need.

"Invisible pain"

In our case, gastrointestinal parasite infections and subclinical mastitis are diseases difficult to *"visualise"* since the *"problem"* they cause is mainly production losses which makes adoption in such programs complicated.

Innovators – brave but rare

Awareness and knowledge alone do not guarantee adoption; it is also important to consider many other factors affecting decision making. Experimenting with new ideas also entails the social risk of being regarded as a maverick. The program may cause resistance to adoption, as can incompatibilities with existing culture, technology or business or personal objectives.

"I don't have time!"

It is understandable that farmers prefer less complex solutions given the increasing load on existing farm labour, a declining population of willing workers, and increasing demands on intellectual and financial resources.

"Who and what do I believe?"

Farmers receive and seek advice from various sources in the private and public sectors, and the influence of these should not be discounted in an extension program.

"I don't like reading"

We need to provide simple, prescriptive and short messages. Farmers utilise a range of information sources and are generally far from a homogenous or

static target population. Levels of literacy, age and willingness to change and reliable access to the internet influence the preferences of farmers when seeking out information.

"Last time I was told..."

Experts and advisers may lose credibility because of poorly understood unsuccessful messages of the past. When these reasons are credible and well communicated, the loss in credibility may be ameliorated.

How we did manage to achieve collaboration with the farmers during the LowInputBreeds project?

- We started off by selecting "key persons" in the area, taking advantage of previous successful collaborations and existing relations with the farmers.
- We tried to connect with each one of them (spend time discussing over a coffee or a meal; participate in local traditional events, etc.).
- We thoroughly explained the need to study what we wanted to study and why those issues were important to them.
- We gave emphasis to the importance of their participation and contribution and to the value of the results to follow which will benefit not only their business but all other farmers in that area as well.
- We presented in full details the experimental plan and what we were planning to do in their flocks and listened carefully to their suggestions which in many case we adapted (we gave them the opportunity to participate and to feel important in the study design).
- We made sure that it was their decision to participate.
- During the course of the study we provided all support possible in terms of veterinary advices and "little gifts" such us vaccines or antiparasitic drugs.
- We always came back with results and practical solutions to make their daily life easier.
- We made sure by constant communication that they follow their program and respect the difficulties they had over time.

Overall, coming to the end of the project, we are happy to say that we achieved a very challenging target from which both ends had a significant gain. Most of the farmer participated now complain because the study ended and state that they will be happy to participate in such studies in the future.

LowInputBreeds Subproject 3

An overview of subproject 3

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The objectives of subproject 3 of the LowInputBreeds project were to identify suitable breeds for low input systems; design dedicated breeding systems; investigate possibilities to breed for heat tolerant sows; reduce piglet mortality by breeding and management; improve product quality by breed choice and feeding regime. Results from literature and surveys show that conventional breeds are well suited for commodity organic pork production in temperate climates with a controlled production environment. The prolific and leaner traditional breeds are suitable for commodity organic pork production, especially when crossed with conventional white boar breeds to give some extra leanness to the carcass. Rotational breeding systems have proven to be a viable breeding structure for the Dutch organic pig sector, especially in combination with AI boars that are ranked according to an organic selection index. Genetic analyses of heat stress tolerance in purebred sow lines have shown that breeding for improved heat tolerance is possible. Sufficient genetic variation in heat tolerance exists within lines. Preliminary results on the effect of gilt rearing environment and genetic merit for mortality on preweaning piglet mortality in conventional *vs.* organic environments, show genotype*environment interactions. Piglet mortality in sows reared in conventional environments was higher for offspring with high *vs.* low genetic merit for mortality. The opposite was observed for sows reared in organic environments. Studies on the effect of breed on dry fermented sausage quality show that under organic farming conditions, Saddlebacks are suitable for heavy (150-170 kg) pig production to produce dry fermented sausages. However, as long as the pay-out price is not adapted to carcass quality or the suitability for processing, the use of Saddlebacks will not be interesting from an economic point of view. From the viewpoint of meat and especially of fat quality, modern hybrids have sub-optimal characteristics for dry fermented sausage production, whereas old purebred Saddlebacks are well suited. This is also true for carcass quality: Saddlebacks have sufficient fat quantities, whereas the modern hybrids represent the lower limit.

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Effect of pig production system on nutritional and sensory quality characteristics of pork in three different macroclimatic zones

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The level of nutritionally-desirable, polyunsaturated fatty acids (PUFA) (including n-3 fatty acids is important in fresh pork products and can be increased by inclusion of fresh forage/herbage in the pig diet. These compounds have been associated with health benefits such as a reduced risk of cardiovascular disease, cancer and arthritis in humans. There is very little information on the effect of including forages into diets on contrasting pig breeds/genotypes (and virtually none for most traditional breeds).

For organic and 'low input' fresh pork production, sensory characteristics are also important to satisfy consumer expectations and/or maintain price premiums. There has been little research into the factors influencing pork flavour quality. One compound that negatively affects pork flavour is skatole, A range of known risk factors for skatole production are more common in 'low input' and especially organic systems. These include pig genotypes/lines with low lean tissue growth rate, excess supply of dietary protein and poor hygienic conditions

A survey was carried out of fat quality parameters (fatty acid composition and skatole) in fat samples taken from carcasses of pigs produced in low input and organic systems in UK, Spain and Austria. A total of 434 samples were analysed for Skatole content by GSMS and a similar number by GC for fatty acid content. Early results from analysis by general linear regression of log transformed skatole results indicated in the UK an effect of gender (higher values in entire males than in females, $P<0.001$) but no effect of production system (outdoor paddock vs indoor straw yard systems). In Austrian samples there was a significant effect of both production system (higher values in indoor pens with concrete runs than in paddock systems, $P=0.010$) and gender (higher values in castrates than in females, $P=0.008$). Mallorcan samples produced low values in general for a traditional breed, however there was an effect of outdoor intensity (higher values in more intensive systems, $p=0.002$) but no effect of gender.

Results of fatty acid analysis are currently awaiting completion.

Effect of heat stress and phosphorus supplementation on pig electron chain gene expression

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The purpose of this study was to evaluate the effect of temperature and different levels of available phosphorus (aP) on the expression of nine genes encoding electron transport chain proteins in the Longissimus dorsi (LD) muscle of pigs. Two trials were carried out using 48 high-lean growth pigs from two different growth phases: from 15 to 30 kg (phase 1) and from 30 to 60 kg (phase 2). Pigs from growth phase 1 were fed with three different levels of dietary aP (0.107%, 0.321% or 0.535%) and submitted either to a thermoneutral (24°C and RH at 76%) or to a heat stress (34°C and RH at 70%) environment. Pigs from growth phase 2 were fed with three different levels of dietary aP (0.116%, 0.306% or 0.496%) and submitted either to a thermoneutral (22ºC and RH at 77%) or to a heat stress (32ºC and RH at 73%) environment. Heat stress decreased ($P<0.001$) average daily feed intake at both growth phases. At 24°C, pigs in phase 1 fed the 0.321% aP diet had greater average daily gain and feed conversion ($P<0.05$) than those fed the 0.107% or 0.535% while, at 34°C pigs fed the 0.535% aP had the best performance ($P<0.05$). Pigs from phase 2 fed the 0.306% aP had best performance in both thermal environments. Gene expression pro• le was analysed by quantitative real-time polymerase chain reaction. Irrespective of growing phase, the expression of six genes was lower ($P<0.05$) at high temperature than at thermoneutrality. The lower expression of these genes under high temperatures evidences the effects of heat stress by decreasing oxidative metabolism, through adaptive physiological mechanisms in order to reduce heat production. In pigs from phase 1, six genes were differentially expressed across aP levels

(P<0.05) in the thermoneutral and one gene in the heat stress. In pigs from phase 2, two genes were differentially expressed across aP levels (P<0.05) in both thermal environments. These data revealed strong evidence that phosphorus and thermal environments are key factors to regulate oxidative phosphorylation with direct implications on animal performance.

Commercial perspective of involvement in the LowInputBreeds project

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In The Netherlands, approximately 60 organic pig production herds exist, with a total of around 5,000 sows. Prior to the start of LowInputBreeds, most of these herds replaced their breeding stock by purchasing gilts from conventional pig breeding herds. This strategy had obvious limitations. Sow replacement rates on Dutch organic herds often average more than 30% of the total number of sows present, whereas EU regulations on organic livestock farming (2092/91) require that replacement rates from conventional origin do not exceed 20% of present stock on an annual basis. Therefore, there was a clear need for alternative breeding strategies. A combined approach of modelling studies and discussions with Dutch organic herdsmen resulted in the design of TOPIGS EkoFok: a breeding structure tailored to the wishes of the organic pig producers. In TOPIGS EkoFok, the best sows in the herd are selected as mother of the next generation of gilts and the breed of boar is changed (rotated) each generation. This so-called rotation breeding allows small herds to exploit crossbreeding in a fully self-contained and sustainable manner. TOPIGS EkoFok is an example of a 'closed' system with on-farm sow replacement: the herd remains closed and only boar semen needs to be purchased for production of replacement gilts or slaughter pigs. Breeding stock originates from the conventional TOPIGS breeding program, but replacement gilts are selected in an organic environment which gives advantages in terms of environment-specific adaptation. Furthermore, TOPIGS dam line boars that are used to produce replacement gilts are ranked according to a specially developed breeding index where more emphasis is given to traits important for organic production, such as piglet survival and mothering ability. Currently, around 50% of the Dutch organic pig herds are using TOPIGS EkoFok with Yorkshire and Landrace sow lines with the highest genetic merit for desirable traits (e.g. mothering ability, piglet vitality, sow longevity) for organic pig production.

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LowInputBreeds Subproject 4

LowInputBreeds: breeding and management for organic and free range egg production systems; Overview of results

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The project aimed at (a) developing a participatory system to test and optimize genotypes of laying hens for free range and organic systems, (b) optimize management for free range and organic farms with specific emphasis on diets and feather pecking, (c) analyse how the productive life of laying hens can be extended and (d) analyse egg quality characteristics.

Basic inputs were interviews with farmers in France, Switzerland and The Netherlands, and observations and discussions during visits of farms in Switzerland and The Netherlands.

The majority of farms use data management programs, more and more on-line and able to produce bench mark information on production. When this information is shared, a practical system for testing of genotypes can become available.

Farmers tend to have a long term relationship with egg traders (Switzerland) or rearing companies (The Netherlands) and these organisations are important in choosing the genotypes.

Although brown egg laying strains are the majority on free range and organic farms in the 3 countries examined, white Leghorn type birds are becoming more popular and the proportion of White Leghorn flocks is increasing.

During the project the gap in production between free range and organic on the one hand and barn and cage production on the other decreased, indicating that management of organic and free range flocks improved and available genotypes were more adapted to organic and free range conditions. Model calculations indicated that only for organic systems and with current feed prices a heavier hen might be slightly more profitable than current genotypes.

In organic production it is difficult to provide the hens with the right quality of protein. Meat and bone meal or insect meal would be helpful, but are for the time being in the EU not allowed in poultry diets. Several types of plant protein are now evaluated as possible replacement for imported soy.

Results on extended laying periods (Maurer, 2014), performance, hens body condition and shell quality (Bestman et al, 2014), fatty acid content of eggs (Chatzidimitriou, 2014) and current breeding strategies (Visscher, 2014) are presented in other papers in this symposium.

Laying hens in organic and free range systems – results of farm visits

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We collected information on commercial organic and free range laying hen farms in The Netherlands and Switzerland, with a range of systems with an increasing degree of intensity from lowest on Swiss organic farms (group size 500 hens and 5 hens/m²) and highest on Dutch free range farms (group size 6000 and 9 hens/m²). We collected information on genotype, housing, feeding, production, egg quality and mortality. Per farm, at an age between 44 to 62 weeks, we scored 50 animals for comb wounds, keel bone deviations, foot pad wounds, belly wounds, feather damage and we weighed them.

We visited 169 flocks: 49 Dutch organic, 25 Dutch free range, 44 Swiss organic and 36 Swiss free range. There were 5 different brown genotypes (86 flocks), 2 white genotypes (35 flocks), 2 silvers (20 flocks) and 1 black genotype (1 flock). Twenty seven flocks consisted of 2 genotypes, mostly brown and white. We saw preferences such as whites in Switzerland and silvers on Dutch organic farms, but all genotypes were commercially available laying hens, which are also used in barn and cage housing. There are no special organic or low input breeds

being used. Mortality at 70 weeks of age was 6.7% in Switzerland and 8.8% in The Netherlands. If free range is compared to organic, then mortality is the same (7.6%). We saw differences in mortality between groups of genotypes, but it is not clear whether these are explained by country or production system. Number of eggs per housed hen was higher in free range (304.0), while feed intake was lowest in free range (120.6) at 70 weeks of age, compared to organic (respectively 295.7 and 124.6). Egg yolks were darker in Switzerland, probably because of addition of natural colourings to the feed. In The Netherlands more hair cracks were seen, perhaps because of more on-farm automation of egg transport. Swiss hens had less wounds than Dutch hens, but we also saw a genotype effect. Mixed flocks had best feather cover (19.43 of a maximum of 24), followed by whites (18.61). Brown and silver hens scored about the same (resp. 17.90 and 17.29). Difference in feather scorings may be caused by differences in propensity to feather pecking behaviour, but numbers of feathers per cm^2 or colour of the feathers may also influence damage.

Prolonging the live span of laying hens

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A major ethical problem of organic and conventional free-range egg production is the discarding of laying hens at around 70 weeks of age. This practice of annual cycles facilitates production planning and helps standardizing egg size and shell quality, but it also produces large numbers of spent hens and, indirectly, male day old chicks that have to be killed. Moulting or keeping laying hens for prolonged periods are two approaches to reduce this problem.

While animal welfare during the moulting period has been studied, less is known about the impact of 'welfare-friendly' moulting on (a) health and immune status during the second laying period (e.g. susceptibility to endoparasites), (b) productivity of laying hens and (c) egg nutritional quality. The second laying period of a moulted flock often only lasts for 30 weeks. Due to breeding the productive life of hens is expanded gradually. Depending on the condition of the flock, egg prices and prices of young laying hens, with current genotypes the 1st laying period can also be expanded by up to 30 weeks without moulting.

Within the performance recording network established within LowInputBreeds in the Netherlands and Switzerland (see abstract by Leenstra *et al*.), health and welfare parameters were recorded for moulted flocks (*field study*). In addition, an *experimental study* evaluating mainly health and egg quality characteristics was carried out with small groups of animals coming from moulted flocks at different ages in the first and second laying cycle.

In the field study, laying periods of about 17% of the flocks were expanded (with or without moulting). In Switzerland, farmers indicated this was mainly because of production planning while in the Netherlands it was mainly for economic reasons. The laying period was extended to 85-90 weeks (without moulting) and to about 100 weeks (with moulting). Flocks were moulted according to a 'welfare-friendly' protocol which granted access to water, oyster shells and wheat bran during the whole process and a minimum day length of 6 hours. Feather and wound scores were good or even very good in the field flocks during both cycles (on average >3.5 on a scale of 1/bad to 4/very good) and mortality was low (5% in 1st cycle and 4% in 2nd cycle, including moulting period).

Results of the experimental study are currently analysed. First analyses indicate that there is no additional build-up of worm burdens during prolonged laying periods.

Expanding the laying period with or without moulting therefore seems to be a good option to mitigate logistic and economic problems without compromising animal health and welfare. As a side-effect it also reduces the number of day-old male chicks to be killed.

Effect of management, season and genotype on fatty acid composition of eggs

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Health benefits of polyunsaturated fatty acids (PUFA) and especially omega-3 (n-3) fatty acids (Simopoulos, 2002) have increased consumers' preference for functional foods. Previous research has shown that egg fatty acid (FA) composition can be manipulated by a variety of factors, such as season (Mugnai et al-., 2014) and strain (Gronas et al., 2001) while the effect of management system (e.g. conventional, organic, low-input) is rather ambiguous (Anderson, 2011; Samman et al, 2009).

The objective of this study was to determine the effect of season (winter, summer) and layer's genotype (Lohmann Selected Leghorn, Lohmann Brown Classic (LBC), H&N Super Nick) reared under 2 management systems (free range, organic) on the FA profile of eggs. Eggs were collected from 13 Swiss flocks within the EU-LowInputBreeds project. A total of 47 FA were identified and determined by gas chromatography. Results were expressed as percentage of total FA and were statistically analysed by ANOVA linear mixed effects model with management, season and genotype used as fixed factors and flock as random factor.

Preliminary results showed that PUFA concentrations, and in particular omega-6 (n-6) and n-3, were significantly higher while monounsaturated FA concentrations were significantly lower in organic eggs compared with free range eggs. However, the nutritionally relevant n-6/n-3 ratio was not significantly different between systems. Season also had a significant effect on FA composition; eggs produced in winter showed higher values of PUFA (both n-3 and n-6). Layers genotype only significantly affected egg saturated FA concentrations, which were lower in eggs from LBC hens. Seasonal differences on the n-6/n-3 ratio were also observed for LBC with ratio being lowest during winter.

In conclusion, egg FA composition was broadly affected by management and season. The impact of genotype was relatively small but showed strong interactions with season. Future work, taking into account the FA profile of the feed used will provide further evidence on the origin of these differences. Further results, including trials from Switzerland and Netherlands will be subsequently published.

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LowInputBreeds Ethical issues

How to strike the balance between breeding for productivity and functional traits of importance for the animal adaptation to their specific environment

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The intensification of livestock production can be described as the exchange of traditional outdoor foraging systems with permanent indoor housing with independence from season and weather conditions, where the feed is provided and feed conversion is optimized.

Low input animal production deviates more or less from these overall characteristics of intensification, either because it exemplifies a continuation of traditional production forms or because it is based on values which contradict pure intensification (e.g. organic production). Across differences about the dependency on outdoor foraging, low input production appears to share the property of allowing freedom of movement for the animals as compared with the strong restraints on the animals in intensive production.

Deviating from the trend of intensification puts low input production under pressure from several sides. One the one hand, the outdoor conditions involves problems of coping with heat or cold and pathogens in the environment; also loosening the restraint involves problems with aggression and larger difficulties in monitoring and controlling diseases. On the other hand, deviating from intensification typically means less efficient feed conversion. This necessitates a price premium in most cases; but the constantly increasing efficiency in intensive production also puts a pressure on low input production to increase productivity.

The demand for higher productivity has led many low input producers to use breeds developed for intensive production. However, this leads to further problems, because these breeds are not well adapted to low input conditions. *LowInputBreeds* is to a large extent devoted to address these problems. Moreover, by using the highly specialized breeds developed for intensive production, low input production is forced to share practices (e.g. killing of male chickens) and to depend on breeding methods used in intensive production, both of which may conflict with the value base underlying low input production or with consumer expectations.

Ethical aspects with regard to productivity and adaptability in dairy cattle breeding systems

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The big increase in milk yield over the last decades (productivity) has been accompanied by declining ability to reproduce, increasing disease incidence and declining longevity in modern dairy cows, resulting in a deterioration of animal welfare; indicating that overall adaptability, defined as the capability to stay healthy and be productive in differing environments, has decreased. This development is due to substantial antagonistic genetic correlations between milk yield and fertility and milk yield and some diseases. It is likely that selection for increased yield also may lead to an intensified environmental sensitivity expressed as genotype x environment interactions.

Most modern dairy cattle breeding programs try to improve functional traits by assigning >50% of the breeding goal to functional traits. Nevertheless, genetic gain in these traits is small compared to production traits, because genetics only account for a small proportion (often < 10%) of the variability of the functional trait (low heritability).

Recently, genome wide selection (GS) has become applicable in cattle breeding and is expected to accelerate breeding programs because breeding values based on marker information become available much earlier with a reasonable reliability than conventional estimated ones. Functional traits linked to adaptability are expected to benefit from GS to a higher proportion than production traits. According to the author´s opinion the practical benefit of GS for functional traits will highly depend on the following conditions:

- Breeding associations publishing genomic breeding values for functional traits

- Prerequisite for the former being:
  - Traits with economic importance and sufficiently strong correlation with the target traits are available and measurable at reasonable costs
  - establishment of routine performance- testing on a wide scale (at least to allow for a training set to be established)
- Farmers getting to understand and explode the potential of genomic breeding values for functional traits (→need of extension)
- Farmer´s practical breeding decisions

Some concerns related to GS are that it might not only improve traits related to animal health, but may also imply a higher risk of accelerating unwanted side- effects e.g. negative effect for non-measured welfare traits and increase the risk of spreading unfavourable mutations. Moreover, the active involvement of farmers into dairy breeding could be reduced (Mark & Sandoe, 2012).

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Balance between productivity and adaptation

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In many low input/organic pig production systems, modern genetic lines are used that are bred in high health environments according to conventional breeding programs. In these programs, emphasis is on genetic improvement in traits that have economic value in conventional production systems. Breeding goals in conventional pig production systems are mostly the same as in low input/organic systems. However, for a good adaptation a few strategies can be implemented. First, both for conventional and low input/organic production systems, it is essential that a balanced breeding approach is pursued. For reproductive traits, this means that genetic progress in traits such as litter size should be accompanied by parallel improvements in number of teats in sows and piglet survival. Another strategy may be to breed for robust sow lines that can cope with challenged conditions, such as heat stress, disease pressure and lower quality diets. Breeding goals of robust sow lines put more emphasis on ease of use traits such as leg quality, feed intake, and sow longevity. Yet another strategy may be to construct breeding indexes that reflect the potential of animals under low input/organic production conditions. Economic values of traits differ between low input/organic and conventional production systems. By applying different economic values and weighing factors for traits in low input/organic systems, indexes are obtained that reflect economic potential of animals in these systems.

The increasing economic prosperity in developing markets such as Asia and Brazil will result in increasing meat consumption. This will lead to higher demands for raw materials for animal feeds, resulting in higher feed prices. It is clear that efficient conversion of feed to animal protein is the main challenge for our industry in the decades to come. At the same, production must be accepted by society in terms of animal welfare, food safety and environmental impact. TOPIGS pursues a whole chain approach where feed entering the production chain is most efficiently converted into live weight delivered to slaughter plants. This so-called optimisation of Total Feed Efficiency is realised by minimising leakages in the system. The TOPIGS breeding program focusses on optimizing sow fertility, sow longevity, pig survival, and feed efficiency of sows and finishers. At the same time, welfare traits such as tail biting, boar taint and overall animal robustness are improved, using modern genetic technologies such as genomic selection.

Poultry egg production systems and ethical issues

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Poultry production systems can be characterized as no/low input or as high input systems. No/low input systems are based on scavenging, kitchen waste and harvest residues. Chickens in these systems have multiple functions, production of eggs, meat, a next generation, pest and weed control, etc. The amount of feed available determines flock size and performance. In general production is far below the genetic potential of the birds due to limited feed resources. The number of birds is low and products are for home consumption and some cash money from a local, informal market. Commercial poultry production (also organic and free range) is specialized (eggs, meat or reproduction), and is based on high inputs. The birds receive a complete diet and are kept in high numbers (several hundreds to ten thousands per farm) in more or less conditioned housing systems. Outside access is provided for welfare reasons, not as a significant dietary source. Feed costs are 70% of total production costs and the products go to a formal market. In specialized egg production systems the brothers of laying hens are killed at hatch, as they do not lay eggs and are not profitable for meat production. They are utilized as food for zoo and pet animals. Killing at hatch is an ethical issue. Often dual purpose chickens, with a higher growth rate, are mentioned as a solution. However, in such hens the amount of feed required for egg production is increased more than what is gained by the better performance for meat production of the cockerels. The most resource efficient solution is to develop a market for the brothers of current laying hens, but they require per unit of meat more feed than specialized meat poultry does. So, a live of significance for the cockerel has to be weighed against resource use efficiency.

Killing cockerels is an issue in organic and free range egg production as well as in conventional egg production. Issues to be considered specifically for organic and free range chickens are risks on infection with Avian Influenza (a zoonosis, significantly more often present in free range and organic systems compared to conventional systems) and pollution of soil and ground water in the outside run with manure. Amounts of nitrogen and phosphate deposited in the first 15-20 m of the outside area might exceed the legal (EU) levels of animal manure application 5 to10-fold.

Such issues indicate that it is worthwhile to reconsider the layout of organic and free range systems and try to develop systems that have the welfare and image of free range systems while risks for zoonosis and burdening the environment are reduced.

The LowInputBreeds Technical Notes[1]

Partners of the LowInputBreeds project have prepared a number of technical notes, which give an introduction to the key themes of the LowInputBreeds project and which summarize key results of the project.

The first notes were published during 2013 and early 2014. They are available at the LowInputBreeds website (www.lowinputbreeds.org) under "Publications".

Technical note 1.1: Genomic breeding programs – a large step forward for low-input dairy cattle breeding?

The increase of milk production in dairy cattle achieved through breeding in recent decades unfortunately has been accompanied by negative side effects on animal fertility, udder and leg health and metabolic stability. Thus, the increase in productivity has not been associated with a similar improvement in longevity of cows. Developing more 'robust' cows and accounting for traits related to animal welfare in traditional and genomic breeding strategies is thought to be a promising approach to find sustainable solutions for the problems listed above.

This technical note gives an overview of the history of dairy cattle breeding, introduces the basic concept and outlines the consequences of genomic breeding strategies especially with regard to functional traits. First results of the LowInputBreeds project in the area of dairy cattle breeding are presented, and limitations and ethical implementations are discussed. Finally, recommendations are given how farmers, especially in the low input sector, should implement the new approach.

› Henner Simianer and Anna Bieber (2014): Genomic breeding programs – a large step forward for low-input dairy cattle breeding? LowInputBreeds Technical Note 1.1. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note: 1.3 Feeding for milk fat quality

Studies from the LowInputBreeds project suggest that cows in organic or low input systems are likely to produce milk higher in beneficial components such as unsaturated fats, vitamins and antioxidants, compared to milk from conventional farms. The impact of dairy products in our diets may be improved, if dairy cows can graze, and milk quality may be improved by feeding oil seeds. Longer-term benefits might be gained, if traits linked to milk fat quality are incorporated into breeding programmes.

› Technical note 1.3: Gillian Butler and Sokratis Stergiadis: Feeding for milk fat quality. LowInputBreeds Technical Note 1.3. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note 2.1: Dairy sheep breeding

In order to optimize dairy production from sheep in the Mediterranean region and avoid high treatment and intervention costs, scrupulous management at all stages of production is required. This task is usually complex, since many factors need to be taken into account including infrastructure, pasture management and nutrition.

In this technical note particular emphasis is given to preventive measures to preserve good health and high reproductive performance of dairy ewes.

› Nikos Tzanidakis et al. (2014): Dairy sheep breeding. LowInputBreeds technical note 2.1. Consortium of the LowInputBreeds project. Newcastle and Frick

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Technical note 2.2: Issues and challenges in organic lamb meat quality

Organic farming promotes pasture-feeding and the 'natural rhythm' of animals, and limits the incorporation of concentrates within diets. This technical note discusses the issues and challenges related to the organic production of high quality lamb meat, and describes possible approaches to how actual problems can be overcome.

› Sophie Prache (2014): Issues and challenges in organic lamb meat quality. LowInputBreeds technical note 2.2. Consortium of the LowInputBreeds project. Newcastle and Frick.

Technical note 2.3: Impact of grazing management on lamb meat quality

In low-input farming systems, particularly in the Mediterranean area, reducing the exploitation of pastures is of interest to farmers. But limiting access to grazing may have a negative impact on the production performance and meat quality of ruminants. Research conducted within the LowInputBreeds project with lambs aimed at determining the impact of pasture management on quality and shelf life of meat, and on lamb performances.

› Giuseppe Luciano (2014): Impact of grazing management on lamb meat quality. LowInputBreeds Technical Note 2.3. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note2.4: Impacts of the diet on sheep milk quality under Mediterranean conditions

Sheep and goat rearing has always been an important agricultural activity in countries of the Mediterranean basin. Professionalization of production and growing awareness of product quality have raised interest among sheep farmers in the relationship between feeding and product quality.

This technical note provides an overview on the interrelations between sheep diet and milk quality, based on research done in Greek sheep farms and other Mediterranean countries.

› Nikolaos Voutzourakis, Smaragda Sotiraki and Alexandros Stefanakis (2014): Impacts of the diet on sheep milk quality under Mediterranean conditions. LowInputBreeds Technical Note 2.4. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note: 2.5 Alternative control of gastro intestinal nematodes in low-input sheep and goat production

Nematodes of the gastro intestinal tract of sheep and goats are of major economic importance because they lead to production losses via reduced growth and carcass weight and/or milk production. In addition, when remaining uncontrolled, these parasitic worms can also provoke anemia or diarrhoea or even mortalities.

Extensive use of synthetic chemical anthelmintics from the pharmaceutical industry, which have been used to eliminate the worms in the hosts, has resulted in worldwide development and diffusion of resistance to the agents in worm populations. Also, there is an increasing demand of European consumers for products from low-input production, which aims at limiting the general use of synthetic chemicals in the farm industry to reduce possible residues in food and/or environmental consequences.

This technical note summarizes results and recommendations from the LowInputBreeds project for controlling gastro intestinal nematodes. These include: eliminating the worm populations in the host, disturbing the life-cycle of worm populations, improving the hosts' response against the worms and reducing contact between vulnerable hosts and infective nematodes.

› Hervé Hoste et al. (2014): Alternative control of gastro intestinal nematodes in low-input sheep and goat production. LowInputBreeds technical note 2.5. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note 2.6: Sainfoin, a natural anthelmintic for small ruminants?

Nematodes of the gastro intestinal tract are of major economic importance in livestock, particularly in domestic ruminants.

This technical note provides an overview of the state of knowledge on sainfoin, a tannin containing legume forage that may play a relevant role in non-chemical control of nematodes of the gastro intestinal tract.

› Hervé Hoste et al. (2014): Sainfoin, a natural anthelmintic for livestock. LowInputBreeds Technical Note 2.6. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note 3.1: Breeding for organic and low input pig production systems

Breeds and breeding strategies for organic and low input pig production systems need to be adapted to the specific characteristics and regulations of this type of production. This technical note presents an overview of research results on this topic, as obtained in the LowInputBreeds project.

› Jascha Leenhouwers (2013) Breeding for organic and low input pig production systems. LowInputBreeds Technical Note 3.1. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note 3.2: Challenges and solutions to problems in pork quality

Meat quality is not particularly well served by modern pig breeding programs. This has led to failures in meat quality, which could en-danger pork's image and economic success of pig production. There is hope these under-lying problems in meat quality can be resolved if there is an economic motivation for producers, induced by consumers.

This technical note gives an introduction to pork quality and outlines solutions to improve it.

› Friedrich Weissmann (2014): Challenges and solutions to pork meat quality problems. LowInputBreeds technical note 3.2.

Technical note 3.3: Saving traditional pig breeds

The establishment of commercial pig breeding programs drastically decreased pig breed diversity. As a result, today, many traditional pig breeds are endangered and risk being irreversibly lost, although there is significant social interest and intention to maintain these old breeds. There are a range of encouraging approaches to maintaining these breeds.

This technical note provides a brief look back on pig breeding and presents successful examples of conservation of genetic resources.

› Friedrich Weißmann (2014): Saving traditional pig breeds. LowInputBreeds technical note 3.3. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note 3.4: Adaptation of sows to rising temperatures

Pork is the world's most consumed meat. With further growing demand pig production tends to move from moderate to somewhat harsher climates. Heat stress is expected to have negative effects on sow production. But as a result of genetic improvement, sensitivity of pigs to high temperatures has increased. This technical note presents an overview of research results on the genetics of heat stress sensitivity of sows, as obtained in the LowInputBreeds project.

› Saskia Bloemhof and Egbert Knol (2013) Adaptation of sows to rising temperatures. LowInputBreeds. LowInputBreeds Technical Note 3.4. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note 3.5: Piglet management in organic and low-input systems

Mortality tends to be higher for piglets born outdoors or under organic management compared with those reared in a more controlled environment.

Scientists in the EU-funded LowInputBreeds project collected knowledge to improve health and survival of low-input and organic piglets, and compiled their findings in the technical note.

› Herman Vermeer (2014): Piglet management in organic and low-input systems. LowInputBreeds technical note 3.5. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note: 4.1 Breeding of Laying Hens

Worldwide most commercial hens are kept in small groups in cages. In some parts of the world there is the trend that laying hens are being housed in large groups and some of them with outdoor access.

This note describes how breeding of laying hens developed worldwide and if and how breeding programs should be adapted for free range and organic systems. Discussions with farmers in France, Switzerland and The Netherlands with free range or organic laying hens at the onset of the Low Input Breeds project on what the ideal hen is for such systems was used as input.

› Ferry Leenstra and Frans Sambeek (2014): Breeding of Laying Hens. LowInputBreeds technical note. 4.1. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note 4.2 Regional high protein feeds for poultry diets

New organic regulations with respect to regional cultivation feed and removal of the permitted inclusion of low levels of conventional feed ingredients calls for regional organic protein production.

This technical note presents options and conditions for a sustainable increase in European organic protein production for livestock feeds.

› Marinus van Krimpen (2014): Regional protein sources for application in poultry diets. LowInputBreeds technical note 4.2. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note 4.3: Egg quality

Egg quality can be considered as both internal egg quality, focusing on the egg content, and external egg quality, focusing on the egg shell. For producers egg size is also important since small eggs can't be sold as table eggs and large eggs have a higher risk to crack.

This technical note discusses the influence of flock nutrition, housing and other aspects of bird management as well as egg storage on egg quality and how this has been investigated under the LowInputBreeds project.

› Thea van Niekerk (2014): Egg quality. LowInputBreeds technical note 4.3. Consortium of the LowInputBreeds project. Newcastle and Frick

Technical note 4.4: Managing free range laying hens

Access to a free range area can improve welfare and health of hens, but only if the farmer recognises problems early and if preventive measures are applied.

In the LowInputBreeds project different breeds of laying hens were compared in free range systems. This technical note gives a practical overview of important aspects to managing free range laying hens.

› Monique Bestman (2014): Management of free range laying hens. LowInputBreeds technical note 4.5. Consortium of the LowInputBreeds project. Newcastle and Frick.

Technical note 4.5: Raising cockerels from free range egg production

Worldwide most males from layer type poultry are currently killed at hatch. Yet farmers with laying hens, consulted in the LowInputBreeds project, revealed they despised this practice and look for possibilities to raise cockerels possibly working with dual purpose chickens.

This technical note explains the best option with regard to resource use efficiency and what production costs might be to raise and market cockerels of specialized layer strains.

› Ferry Leenstra (2013) Raising cockerels from free range egg production. LowInputBreeds Technical Note 4.5

Publications of the LowInputBreeds project

Publications of the LowInputBreeds project can be downloaded at the project website www.lowinputbreeds.org > Publications.

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