



Prof. Dietmar Flock,
Editor

Editorial

I am writing this editorial on **World Food Day**, 16th October 2010. The Food and Agriculture Organization of the United Nations (FAO) reminds us that an estimated 1 billion people suffer from hunger. The growing world population with increasing per-capita demand for animal products appears to be a good business opportunity for the global animal agriculture, but we have to be aware of the increasing pressure of our society to develop more animal-friendly systems of production and to reduce the impact of green house gas emissions.

In this issue, we offer the following papers as “**food for thought**” in the context of producing safe food from healthy animals:

1. In his key note address at the World Congress on Genetics Applied to Animal Production, held in Leipzig, Germany, in early August, **Prof. Joachim von Braun**, University of Bonn, reviewed “**The role of livestock production for a growing world population**”. The rapidly increasing demand for animal products needs a strategy for the global livestock economy to serve world food security, applying innovative production technology adapted to changing consumer behavior, and a big push to enhance overall efficiency of livestock production.
2. The “big push” demanded by Prof. von Braun requires that young professionals get the best possible education. At the European Poultry Conference in Tours, France, a special session was dedicated to educational opportunities. **Prof. Johan van Arendonk et al.**, Wageningen University, The Netherlands, called attention to a new program designed to acquire a “**European Master in Animal Breeding and Genetics**”, which may also be of interest to some of our readers.
3. In their attempts to improve the efficiency of poultry production, primary breeders keep looking beyond simple input-output relations. Can emissions from poultry houses be reduced by genetic selection? This question was investigated in a study by **Dr. Wiebke Icken** and **Prof. Rudolf Preisinger**, Lohmann Tierzucht: “**Selection of laying hens for improved consistency of excreta**”. The simple technique used requires single cage management to collect records from large numbers of fully pedigreed hens. The genetic parameters are encouraging.
4. **Dr. David Cavero et al.**, Lohmann Tierzucht, present estimates of genetic parameters from commercial white-egg and brown-egg populations in their paper “**Genetic evaluation of pure-line and cross-line performance in layers**” and discuss implications for practical breeding. These parameters are used to optimize breeding plans for adaptation to prevailing field conditions.
5. Vaccination of chickens against *Salmonella* Enteritidis and *S. Typhimurium* has been used in Germany and other countries for several years and is considered as a major contribution to Biosecurity and food safety. In the paper by **Dr. Nathalie Desloges et al.**, Lohmann Animal Health, “**Development of a third generation vaccine to prevent *Salmonella* infections in commercial poultry flocks**” the authors report test results with a new combined vaccine, which appears to be safe and efficacious after challenge infection with virulent strains of both serovars.

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6. Unfortunately the risks of *Salmonella* infections are not limited to the two serovars *S. Enteritidis* and *S. Typhimurium*. Next on the list is *S. Infantis*, as explained in the paper by co-authors **Dr. Tatjana Miller *et al.*** from three German Research Centers: “**Epidemiological relationship between *S. Infantis* isolates of human and broiler origin**”. The authors suggest that successful control of *S. Enteritidis* and *S. Typhimurium* may lead to an epidemic increase of *S. Infantis* in broiler populations and advocate monitoring by routine application of a new phage typing scheme.
7. **Prof. Hans-Wilhelm Windhorst**, Institute for Spatial Planning in Areas of Intensive Agriculture (ISPA), reviews “**Patterns and dynamics of egg production in sub-regions of Europe**” during the past two decades. The results are of special interest in connection with the phasing out of conventional cages, demanded by EU regulations for all member States.
8. The “**Present status of the world goat populations and their productivity**” is reviewed in the final paper by **Prof. Mahmoud Abdel Aziz**, King Faisal University, Al-Ahsa, Saudi Arabia. The significant increase of the global goat population reflects developments mainly in China and Africa, where goats play an important role for the livelihood of the rural population. Genetic programs to improve meat and milk yield are discussed in the context of adaptation to marginal environmental conditions.
9. The reorganization of Federal Animal Research in Germany reinforces the focus on consumer protection and food safety. In the context of consumer demand for safe food from healthy animals, vaccination against viral diseases is of special interest. So it seemed logical to place the headquarters of all German Federal Animal Research Institutes in Riems, where Friedrich Loeffler and his colleague Paul Frosch became famous as founding fathers of virology. **Prof. Dr. Dr. h. c. Thomas Mettenleiter, Prof. Dr. Timm Harder and Elke Reinking** briefly report from the centennial under the title “**100 Years Friedrich-Loeffler-Institut**” and list recent publications on HPAI based on research activities of the FLI in Riems.

With kind regards,



Prof. Dietmar Flock,
Editor

The role of livestock production for a growing world population*

Joachim von Braun, Bonn, Germany

Introduction

The science which the participants of this World Congress on Genetics Applied to Livestock Production engage in and the science frontiers they are pushing forward are extremely important to the wellbeing of mankind. Innovative breeding and reproductive technologies in livestock production are as fundamental for global food security as is plant breeding.

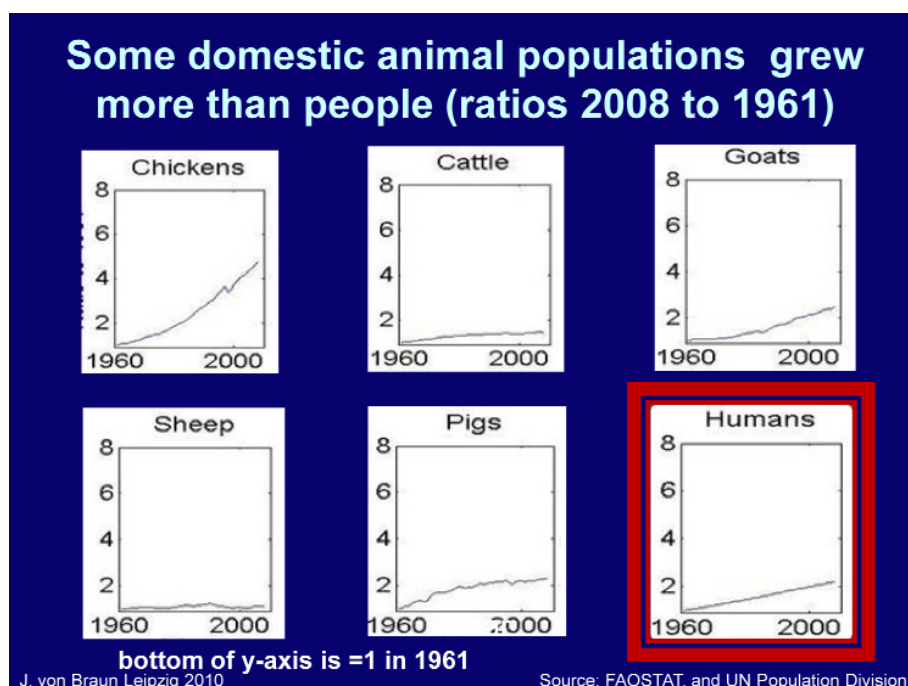
This presentation will cover population concerns and food insecurity; production and income issues; consumption; health and nutrition; environment, and the required policy action. As this is a rather wide-ranging set of issues I offer you my two main conclusions:

- a strategy for the global livestock economy that serves world food security requires new technology and adapted consumption behavior and
- a big push to enhance livestock productivity is needed for global food and nutrition security.

Populations

The world population of 2050 will be roughly nine billion. The good news is there will probably be not more than nine billion, but they will eat like twelve billion people would eat today. The human population has more than doubled since 1960. Some domestic animal populations, however, grew more rapidly than people did (figure 1). The World chicken population quintupled since 1960, and is predicted to increase further from currently 19 billion to at least 30 billion by 2015. Numbers of pigs and goats roughly kept up with human population growth, whereas cattle and sheep populations have grown less in numbers than people.

The composition of the world animal herds is changing, and the good news is the herd structure is changing towards better feed efficiency. That explains why there are more chickens and relatively more pigs, but less cattle and sheep. The significant growth of the goat herds seems puzzling, but is an expression of improved wealth of people in some marginal areas of the developing world (graph 1).

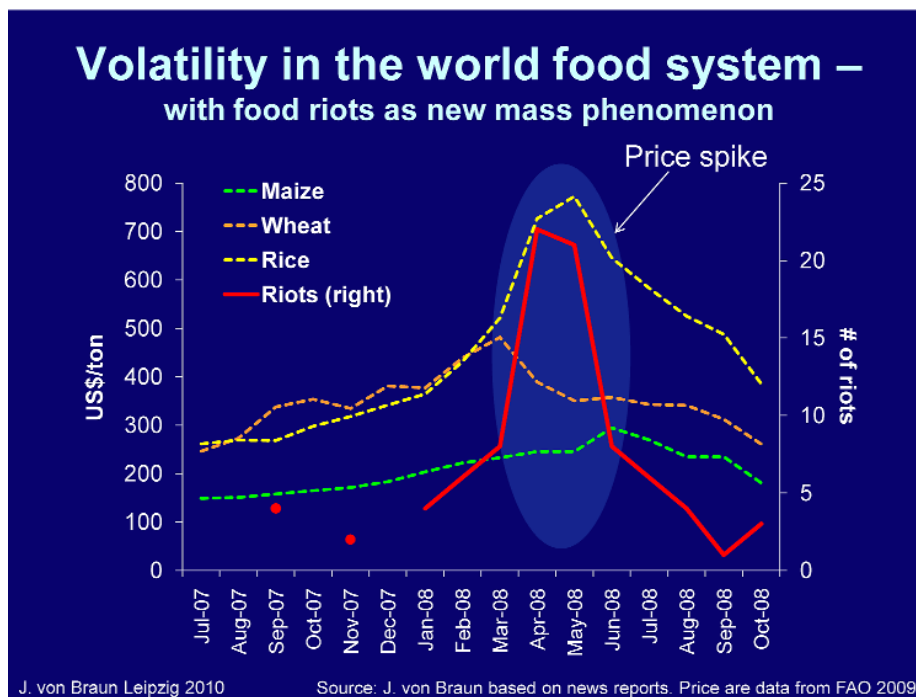


* Keynote address at the 9th World Congress on Genetics Applied to Livestock Production, Leipzig, Germany, August 1, 2010

There will not only be more people on the globe, but they will also be more urban and they will be richer and they will demand more water- and land-intensive foods, such as meat, milk and fish. At the same time, it is depressing news that in the last few years hunger has further increased in the world. The absolute number and, in the last two years, even the relative proportions of hungry people have risen. According to recent FAO estimates, the number of undernourished people is about one billion. This estimate refers only to calorie-deficient nutrition, a much larger number suffers from protein and micronutrient-deficiency.

Volatility

The world food system has become more unstable, volatility is an issue that affects all aspects of the agricultural market and production systems. The following graph 2 illustrates that fact through the ups and downs of prices which have occurred over the last two to three years.



J. von Braun Leipzig 2010

Source: J. von Braun based on news reports. Price are data from FAO 2009.

The price spikes of 2008 are well remembered in the animal production community. People suffered but also livestock producers suffered because feed was becoming so expensive. The food crisis multiplied the number of poor and hungry people in low income countries. But something in addition happened: as shown in the graph, the frequency of protest, some of them quite violent, increased around the world in the context of the world food price crisis. There were more than 60 such events and several governments toppled over the protests. People don't put up with an unstable world food system anymore.

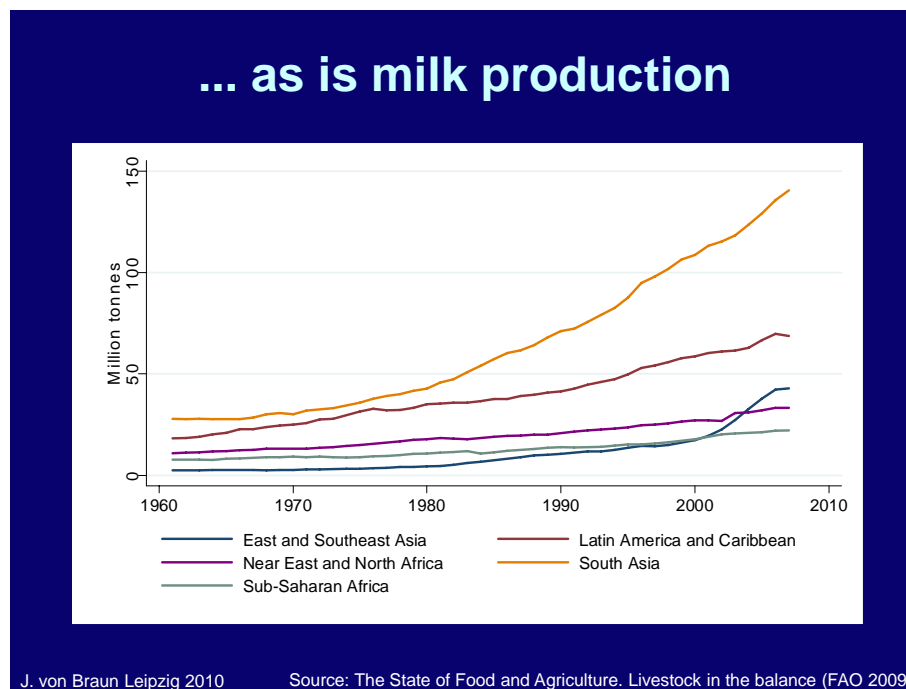
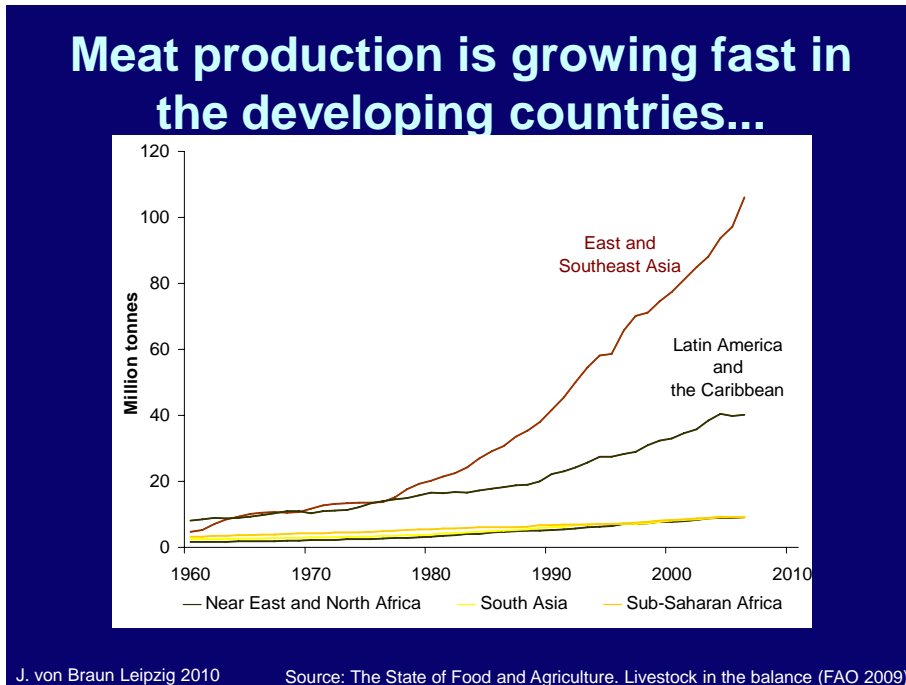
Production

Livestock and its inputs are a growing economic sector. The livelihood and income effects of the livestock economy are huge. More than a billion people keep livestock, 60% of rural households do so. It's a major income source of the poor and especially of women in developing countries. The dairy industry in particular, plays a strong role for the livelihood of poor people. The livestock capital as part of the overall agricultural capital amounts to more than a quarter. Land valued at market prices is about half. Livestock capital is therefore a very important element of the overall capital stock of world agriculture.

Meat production is growing fast, especially in the countries of East and Southeast Asia. The growth rates are exponential. Latin America, the Caribbean, and Brazil also play an important role and show

a very significant growth in meat production. Milk production did not grow quite so fast. It is mainly India, which drives that global supply upward.

Graphs 3 and 4: Growing production of meat and milk



There is a lot of debate about the relationship between animal production and water. Some of the debate is rather simplistic, discussing only the water footprint, the virtual use of water through the livestock sector. It is necessary to look deeper into the issue. The implicit use of water for animal production is indeed significant and as climate change will make water availability an increasing problem, the whole livestock production sector needs to become more water-efficient, especially in the world's dry zones. Water availability will change regional comparative advantages even more than in the past.

Genetic Resources

Among the inputs of the livestock economy the genetic resource base is a key one. It's of great value, but assessing that value is not straight forward. First, there is its market value; second, genetic traits have an insurance value (to fend off future risks); third, it also has an intrinsic inheritance value (preserving traditional breeds, developed by our ancestors). The national ownership of the genetic resources is protected by general international law but with it comes responsibility for conservation and for sharing. This Congress includes a session which follows up on the International Conference in 2007 on livestock genetic resources, organized by FAO, which plays a crucial role in that respect.

Demand

Demand drives the growth of the livestock sector. Not only in the livestock production domains, but generally in agriculture the world is currently in the middle of a paradigm change. Already, many countries shift from a market- and commodity-oriented sector to a food systems concept. Agriculture moves from being supply-driven to a demand-driven sector – focusing on serving consumers, and anticipating what consumers will want in the future. In the context of that paradigm change, agriculture will turn toward a broader concept of “bio-economy”. Bio-economy is the cross-cutting economic sector that embraces all the different bio-based raw materials and conversions from biomass to other highly valued materials.

The animal genetic research community will also become more demand-driven and bio-economy oriented in the future. The consumption of animal products will be driven by changes in population size, available family income, relative food prices, taste and preferences. The transformation from traditional markets to complex food systems will continue, not only in developed countries. The consumption curves for the major world food items depicted in graph 5 show a steep upward trend, especially for eggs, meat, gentler for milk. These trends are in contrast with the basic staple foods which are shown at the bottom of the graph, the cereals, the roots and tubers, and potatoes. Animal production is really in the high -growth segment of the world food system compared to the staple food sector. Meat consumption per capita is also approaching similar levels across the world.

As illustrated in graph 6, where per capita meat consumption is plotted against per capita income for different countries, meat consumption is income-driven up to a very high point and the world is far from reaching that point. One can guess how long it will take to reach that income level. The desired meat consumption - given today's consumption behavior - will require at least a doubling of per capita meat supply once the world has reached these income levels, which may happen within this century.

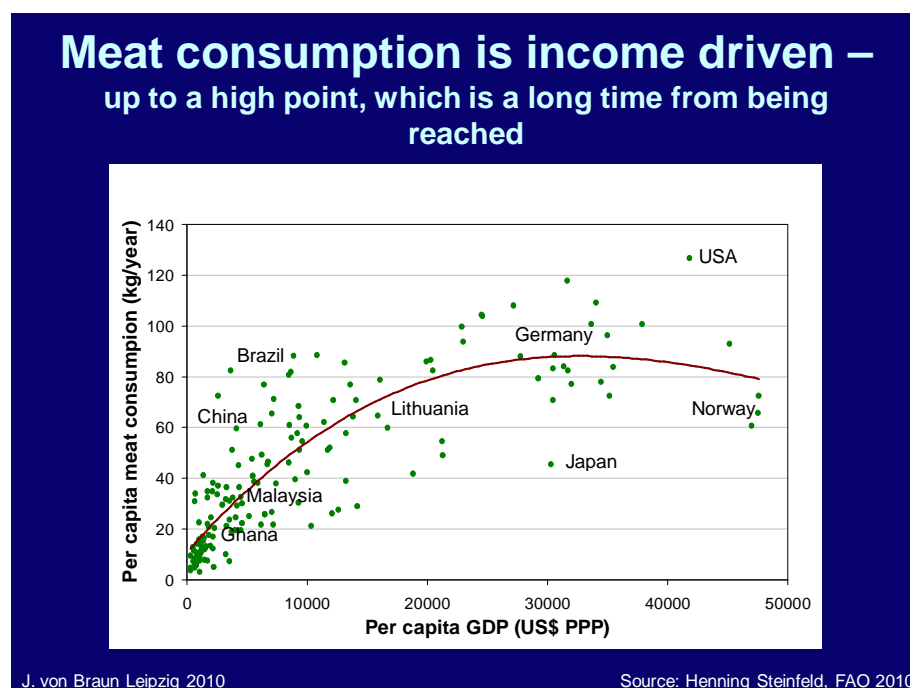
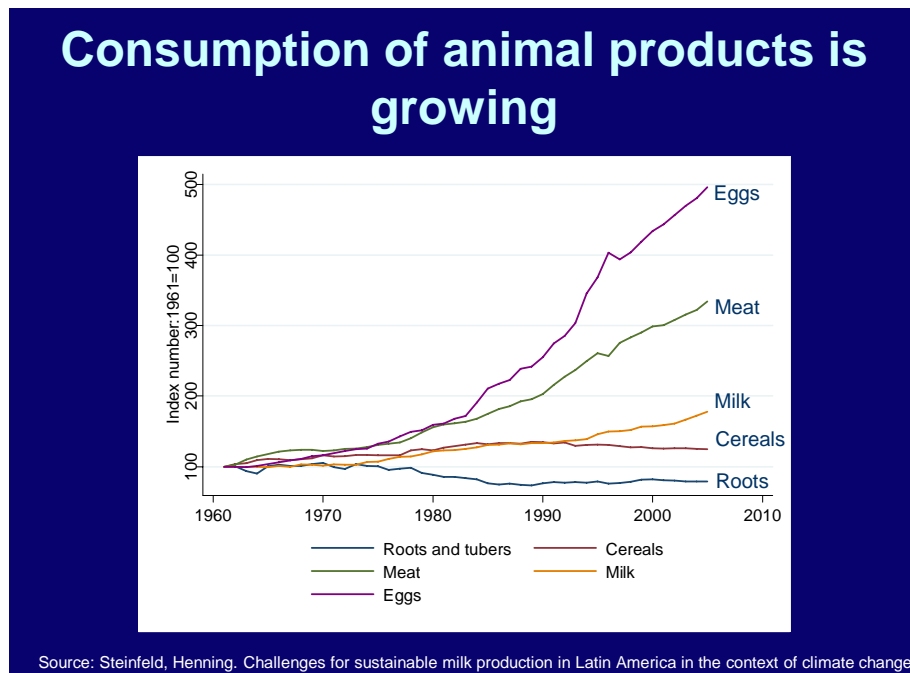
Consumer reaction to increasing meat prices is generally strong. A recent review looking across more than 400 studies of the price elasticity of meat shows that a 1% increase in prices presses meat demand down by 0.5 %. That's a very important issue to keep in mind because pricing and taxation of meat would reduce demand. If we run into supply constraints and prices go up, consumers will react promptly and the poor will have to respond stronger with consumption reduction than the rich, because of income constraints.

Taste

Eating meat and drinking milk has deep roots in human evolution and culture. The question if people will change their taste is a very important one for the sustainability of the livestock economy and of the agricultural system. An interesting fact is that over the last few decades the prices of fruits, vegetables and bakery products, especially of fruits, vegetables and pulses, have increased more than for animal products. So, relatively speaking, animal food has become cheaper. Therefore, consumers shift more and more to animal products, which may lead to obesity and health problems. There has been a lively debate among policy makers and economists about how to correct this problem. Price policy, for instance a meat tax, and a fat tax, have been discussed, for instance at the World Health Organization.

The diversity of taste is still large: For more than a billion people consumption of pig meat is forbidden, but in the Chinese language pig means home, and pig meat is happily consumed if the price is right. Around the world different attitudes drive human behavior and are enshrined in their culture. Apparently it is easier to increase the efficiency of animal production than to change consumption behavior.

Graph 5: Increasing consumption of animal products, compared to cereals and roots



People's and Animal's Health

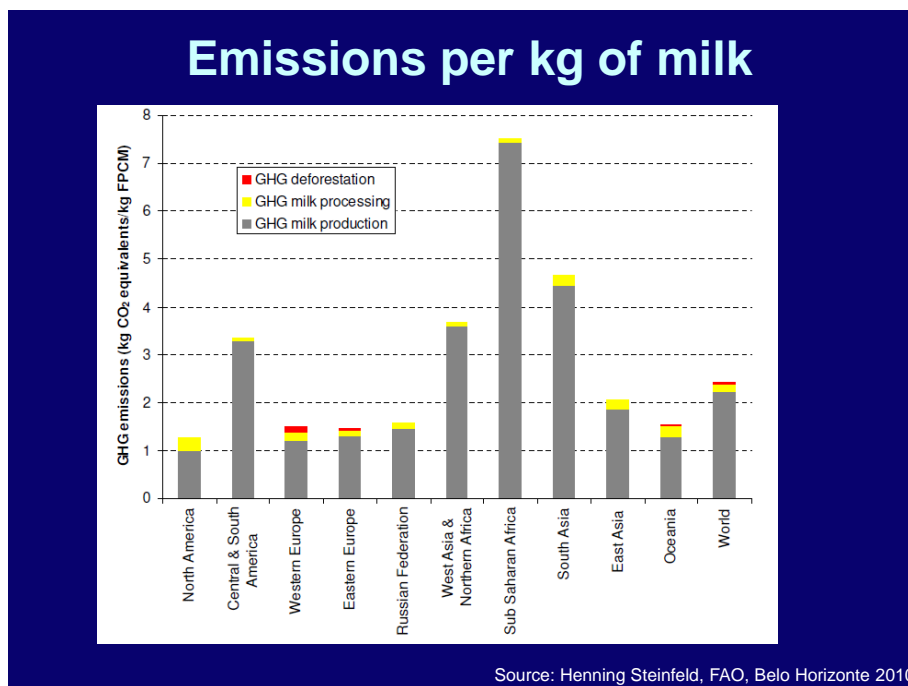
People's and animals' health are linked and must improve together. These are complex issues. They call for more research on zoonotic diseases, antibiotic resistance, excess consumption of livestock products, and children's nutrition and meat consumption. Regarding the latter issue, there is some exciting new research from the nutrition community: Animals contribute not only significant shares of calories but also of healthy diet ingredients to human consumption, and there is a connection between meat and children's diet which helps to improve cognitive function and initiative.

Results of the first randomized trial on the effects of incremental meat consumption among school children in twelve schools in Kenya are published by Neumann et al (2007) in the Journal of Nutrition (J. Nutr.137:1119–1123, 2007). All children received the same calories, but the composition of their diet was different to compare the effects of supplementation with either more milk or more meat or more

fat. The meat group showed the steepest increase in cognitive functions, in learning abilities and achievements. The meat group also showed the largest nutritional impact on the children with respect to the time they were able to spend on high-level physical activity and on their leadership behavior. There is something to meat which is difficult to substitute, a calorie is not a calorie; a protein is not a protein. When talking about meat and health one must not only look at the downsides of excessive meat consumption but also at the upside of increased shares of meat in the diets of the poor.

Environmental Footprints

The environmental and greenhouse gas footprints in the context of livestock production need to be addressed too. Climate change and greenhouse gases make matters more complex when developing an efficient and sustainable strategy for the animal production sector. Ways must be found to reduce livestock emissions along the whole food value chain, not just a trick here or there. Emissions from feed production, emissions from livestock rearing and from processing and transport should be decreased significantly. A particularly important aspect is the emissions from feed production, namely the indirect land use effects of the animal production sector, pushing at rainforest use and conversion of pastures. Of prime importance, however, is productivity. Comparing the greenhouse gas emission per kg of milk, in Western Europe with Sub-Saharan Africa and South Asia, shows that productivity and efficiency increases are environment-friendly, which is often overlooked (see graph 7 below).



Ethics

Consumers are demanding and not always easy to please when it comes to food quality. Global consumers of animal products want their food to be: (1) affordable, (2) healthy, (3) nutritious, (4) safe, (5) environmentally friendly, (6) culturally acceptable and (7) fair to the animals. Rich and poor consumers value each of these criteria differently. Animal production therefore needs to pay attention to ethics, economics, science, and communication. Ethics in food and agriculture must facilitate actions to end hunger and malnutrition of people, but it must also respect the wellbeing of the animals. Animal science must engage in two ethical problems. First, when there is no general understanding of what is ethical then it is largely a communications and awareness issue to inform people. Secondly, when there are recognized ethical principles and they are violated, it is an issue of regulations and law. Not all what is scientifically feasible is accepted as ethical, and perhaps the professional community of animal geneticists can learn from the medical profession in ethical issues.

Conclusions

What happens if the science and research investments in agriculture are stagnating? The sad answer is: food and nutrition security will deteriorate further. The science of animal production must continue to push at frontiers in animal genetics: design of breeding programs, genotype-environment interaction, genomic selection, disease resistance and support animal welfare - productivity related tradeoffs. Research on synthetic and hybrid meat and milk products should also be on the agenda. Innovative and new technologies are required in animal production, and communicating the advantages of innovations to farmers and consumers must be an integral part of this. More cooperation among scientists, media, and policy makers is needed to make science communication more effective – not propagandistic advocacy of pro or against innovation.

A strategy for the global livestock economy serving food security requires new technology and changing consumption behavior. A big push to enhance livestock productivity for global food and nutrition security is needed now.

Zusammenfassung:

Die Rolle der Tierproduktion für die wachsende Weltbevölkerung

Die Weltbevölkerung nimmt weiter zu und dürfte im Jahre 2050 etwa 9 Milliarden erreichen. Die Zunahme findet hauptsächlich in Entwicklungsländern statt, wo die gleichzeitig steigende Kaufkraft einer wachsenden Mittelschicht auch die Konsumgewohnheiten verändert. Nimmt man beide Faktoren zusammen, so entspricht der zu erwartende Fleischkonsum dann 12 Milliarden Menschen mit heutigem Durchschnittsverbrauch. Entsprechend muss die Tierproduktion ausgeweitet werden, um dieser Nachfrage gerecht zu werden. Die damit verbundenen Risiken für die Umwelt und die Gesundheit von Menschen und Tieren sind eine Herausforderung für die Wissenschaft und Praxis der Tierproduktion.

Die Produktivität der Tierproduktion hat in den zurückliegenden Jahrzehnten stark zugenommen, sowohl hinsichtlich gesteigerter Leistungen pro Tier wie auch in einer Senkung der Produktionskosten, z.B. in der Milchleistung je Kuh und verbesserter Futtermittelverwertung bei Schweinen und Geflügel. Die Konkurrenz zwischen Tierfutter und Pflanzennahrung für den Menschen wird weiter verschärft durch die Nutzung von Biomasse zur Energiegewinnung.

Die Beherrschung von Gesundheitsrisiken in Tierpopulationen, die globale Kontrolle zoonotischer Erreger und die Minimierung von Rückständen in Nahrungsmitteln tierischen Ursprungs dürften an Bedeutung gewinnen. Klimaveränderungen durch Treibhausgasemissionen von zunehmenden Tierbeständen und geänderter Bodennutzung müssen vermehrt beachtet werden. Gleichzeitig wird der Tierschutz eine größere Rolle spielen und herkömmliche Produktionsmethoden in Frage stellen. Effizientere Tierproduktion bedeutet in aller Regel weniger Umweltbelastung, und moderne Produktionsverfahren bieten höhere Standards für die Sicherheit von Lebensmitteln und Tiergesundheit.

Die Vielfalt der Produktionssysteme ist eine gute Voraussetzung für die weitere Entwicklung. Die Tierhaltung trägt maßgeblich zur Verbesserung der Lebensqualität für die Landbevölkerung in Entwicklungsländern bei. Rund eine Milliarde Menschen halten Tiere, und für 60% der ländlichen Haushalte ist der Verkauf von Tierprodukten eine wichtige Einkommensquelle.

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European Master in Animal Breeding and Genetics: international collaboration to face future needs

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Introduction

The integrated European Master of Science program in Animal Breeding and Genetics (EMABG) aims to offer high quality international training in its domain. EMABG is developed by a consortium of universities from six EU member countries. In 2007, EMABG was recognized as Erasmus Mundus course by the European Commission which resulted in funding for a period of 5 years. The first group of students started in August 2007. The EMABG aims to provide a European dimension in the knowledge-intensive area of farm animal breeding operating internationally. European animal breeding organisations are world leaders, with global market shares of up to 90%. The success of European breeding owes much to its longstanding close ties with universities and research institutes, fostering the dissemination of knowledge to the farm and individual breeder level. There is an increased need for people with a MSc degree in animal breeding worldwide, but the number of graduates is currently decreasing. The EMABG provides a response to the need for highly qualified graduates, as well as to the need to adapt education systems to the demands of the knowledge society. This paper presents the background and overall objective of EMABG, the content of the MSc program and the experiences of the first years.

Background

Increased demand for a diverse, sustainable and plentiful supply of food at affordable price represents a challenge for agricultural systems. Livestock breeding is at the top of the animal production pyramid and hence defines the quality of all animals used in agriculture. Farm-animal selection has a great impact on farm-animal production as a whole, because the breeding response is cumulative and sustainable. Efficient reproduction techniques, such as artificial insemination, allow genetic improvement to be rapidly disseminated throughout the production chain. Europe has always played an important role in improving the major farm animal species worldwide, but as the 21st century begins, farm animal breeding is at a crossroad.

Opportunities for animal breeding and reproduction stem from the global need for a sustainable increase in food quality and quantity, as well as production efficiency. Food consumption of animal origin is expected to grow by around 7% yearly over the next decade, and to keep rising for the next 15-20 years worldwide. Much of this increase will be in developing countries. Improved quality means safe, healthy food and robust, healthy animals. An improvement in production efficiency can help to reduce the impact of animal production on the environment. The overall objective is to promote breeding of farm animals that is both biologically and economically sustainable, taking into account social responsibility and cultural and regional values.

Breeds of domesticated farm-animal species (including fish) are the primary biological capital for livestock development, food security and sustainable rural development. Indigenous farm animals may appear to produce less than highly specialized exotic breeds, but the indigenous animals are highly productive in their use of local resources and are more sustainable over the long term. Cutting-edge agricultural technology is needed to make best use of local genetic resources, but technology has to be set in local contexts and be applied in ways that recognize the special conditions of poor farmers.

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To tackle the increasing needs for qualified graduates, six European universities jointly developed the two-year European Master of Science program in Animal Breeding and Genetics (EMABG), implemented as an Erasmus Mundus masters program with EU support, mainly scholarships. The EMABG aims at building capacities in the fields of animal breeding and genetics to meet the following challenges in developed and developing countries:

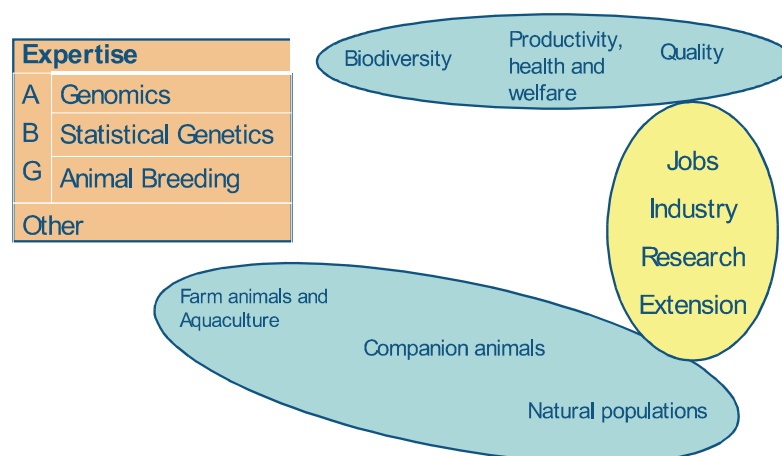
1. increase of livestock and fish production, while preserving the quality of the products and the welfare of animals;
2. development of sustainable animal breeding programmes that contribute to improved livelihood of farmers and efficient food chains;
3. development of sustainable breeding programmes that contribute to improved health and welfare of companion animals (including populations in zoos and nature reserves);
4. preservation of natural resources, especially biodiversity, which become scarcer and scarcer.

The EMABG is based on mobility of people, exchange of experiences among disciplines, and the establishment of a common high quality standard in higher education and training. The consortium brings together a broad range of complementary expertises, not only from the disciplinary or thematic perspective, but also from the experiences in developing countries, where each partner has strong research commitments.

Content and organisation of the MSc program

The scope of the EMABG MSc program is illustrated in Figure 1. The EMABG concentrates on use of quantitative and molecular genetics for animal breeding purposes. This involves a range of species of farm animals (ruminants, pigs, poultry and horses), fish and other aquatic species, companion animals, as well as natural populations (in wild or zoos). For farm animals and aquaculture, the genetic concepts is discussed in a holistic view, considering the role of animal breeding in the production system and the global use of animal genetic resources for agricultural and various society needs. Knowledge on animal breeding and genomics is used on themes such as animal welfare, sustainability, food security, food quality and safety, ecology, as well as other animal functions such as companion and sport.

Figure 1: Scope of the European Master in Animal Breeding and Genetics



The EMABG is truly international and has many links to global research and to capacity building in developing countries. The expected learning outcomes of EMABG are presented in Table 1. The length of the EMABG is 2 years (120 ETCS). Each student spends the two years of the MSc program at two different participating universities. Two joint courses for all students are organized: an introduction course at the start and a one week summer course between years 1 and 2. EMABG builds on

existing MSc programs in the participating universities. It consists of required and elective subjects: disciplinary and complementary subjects, problem oriented study, and thesis research. EMABG students follow courses jointly with the university's other students. EMABG offers a tailor-made study plan that meets the needs of the individual student. Coherence and quality of the study plan are discussed and approved by the EMABG study coordinators at the respective universities to ensure that the study plan meets the requirements to award a double degree. Around 20 scholarships are provided yearly. Information about EMABG is available at www.emabg.eu

Table 1: Learning outcomes of EMABG in terms of Dublin descriptors

Qualification item	Description
Understands the language of one or more disciplines	Capable of understanding other disciplines and of placing own discipline within a multidisciplinary framework
Capable of conducting research	Can do research independently and use the correct instruments
Capable of designing solutions (analyse and combine knowledge)	Can define problems, collect information and design solutions independently
Has a scientific approach	Knows about current debates in scientific practice, can critically analyze theories and document results
Is aware of the international context	Can operate independently in an international context (in terms of both content and social-cultural aspects)
Is aware of the social context of problems/ dilemmas	Integrates the social consequences of developments into the work and takes a stand as an expert
Is competent in collaborating and communicating	Is able to debate and to function as team leader

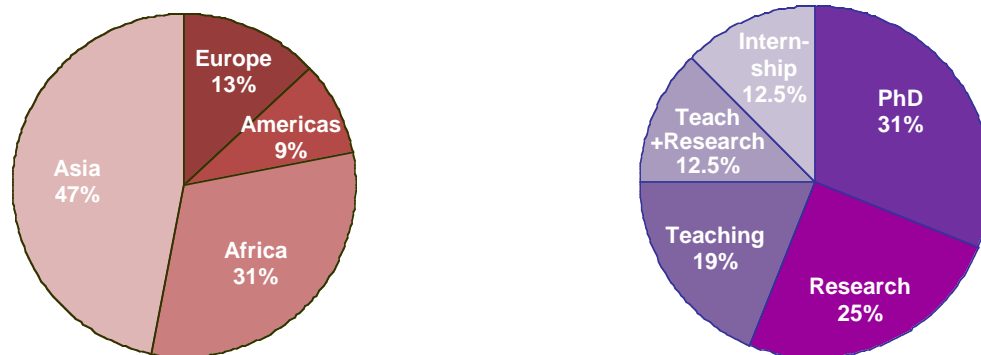
Participation

In the first year, we received 240 applications. After the selection procedure, 24 students started the program in August 2007. In subsequent years, the number of applications increased to over 300 in 2010. The number of students that started the program has varied between 22 and 25. The students originate from 33 countries mostly from Africa and Asia (Figure 2). However, we have observed a slight increase in participation of EU students, a trend that is expected also in coming years due to availability of scholarships for EU students. In 2009, 23 students successfully completed EMABG and found a job soon after. A relatively large proportion obtained a research or PhD position within or outside the EU (Figure 2).

So far, students enrolled in EMABG have been highly motivated in their studies, and overall their study results have been very good. Most of the students are very pleased with their EMABG studies. The students stay in close contact with each others and also with the regular university students. The joint EMABG events, i.e. introduction course, summer course between the two years and a joint graduation ceremony are important for connecting the students, as well as the EMABG universities. Already the first batch of students formed an EMABG student union and an alumni network. Minor difficulties to mention are coping with the differing formal requirements between universities.

An important positive effect of EMABG is that it contributes to internationalization of the regular teaching at the participating universities, meaning also that interest and understanding of international issues increase among the national students of that university. EMABG also leads to increased contacts between the participating universities, and enhance the profile and visibility of higher education in the European Union.

Figure 2: Continent of origin of students that started EMABG between 2007 and 2009 and overview of jobs of students that graduated in 2009



Summary

The European Master in Animal Breeding and Genetics (EMABG) is a two-year MSc program provided by six EU university groups with an active training and research program in the field of animal breeding and genetics. The EMABG is a response to the need of highly qualified graduates in the internationally operating area of breeding farm animals and fish, and animals for other purposes. The EMABG is recognized by the European Union as an Erasmus Mundus MSc program for a five-year period and started in August 2007 with a group of 24 non-EU students. The students conduct the major part of their training at two of the participating universities, and also gather for joint EMABG events. Successful students are awarded two national masters degrees (double degree).

Zusammenfassung

Europäischer MS Studiengang in Tierzucht und Nutztiergenetik

Der Masterstudiengang 'European Master in Animal Breeding and Genetics (EMABG)' umfasst zwei Jahre und geht auf eine Initiative von sechs Universitäten innerhalb der EU zurück. Er beinhaltet ein aktives Studien- und Forschungsprogramm auf dem Gebiet der Tierzucht und Nutztiergenetik. Der EMABG-Studiengang wurde implementiert, um die Nachfrage nach hochqualifizierten Studienabgängern im internationalen Sektor der Zucht von Nutztieren, Fischen und anderen Tierarten zu befriedigen. EMABG wurde von der Europäischen Union als ein Erasmus-Mundus Masterprogramm für einen Zeitraum von 5 Jahren genehmigt und startete im August 2007 mit der ersten Gruppe von 24 Studenten aus Ländern außerhalb der EU. Die Studenten absolvieren den größten Teil des Studiums an zwei Partneruniversitäten und treffen sich darüber hinaus bei gemeinsamen Veranstaltungen im Rahmen des EMABG-Programms. Studenten, die das Programm erfolgreich absolvieren, erhalten zwei nationale Masterabschlüsse (double degree).

Reference

Scholarships for participating in EMABG: see www.emabg.eu

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Selection of laying hens for improved consistency of excreta

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Introduction

Ammonia (NH₃) emission is a major concern for the poultry industry, including laying hens. KLING and QUARLES (1974), CARLILE (1984) as well as DEATON *et al.* (1984) showed that excessive levels of NH₃ may adversely affect health and production by contributing to corneal ulcers, decreased lung function, lower egg production and reduced body weight gains. As a more general problem, it is of environmental concern as an aerial pollutant in closed houses and exhaust ammonia to the environment.

In commercial cage systems, the widely used ventilation of the manure belt reduces the problematic ammonia emission effectively. The ventilation immediately dries the manure and the NH₃ emission is minimized. In floor housing systems, however, ventilated manure belts are uncommon because of relatively high cost, and not possible for free-range systems. Therefore, feed specialists as ROBERTS *et al.* (2007) and POTTGÜTER (2008) investigated the influence of feeding fibre enhanced diets on the dry matter content of laying hen excreta and ammonia emission. The more exact method to determine moisture content applied by de Verdal *et al.* (2010) is not considered as practical for large numbers of hens in a commercial breeding program.

The objective of the current study was to determine whether individual differences can be determined subjectively with sufficient accuracy to serve as basis for genetic selection as a long-term approach to minimize environmental pollution. Individual observations on the consistency of the droppings of fully pedigreed hens in individual cages were collected and analyzed together with the conventional performance traits to estimate genetic parameters.

Material and methods

The weekly individually taken droppings of 9,194 White Leghorn hens of 5 LSL strains, housed in two identical single cage houses, was scored in regard to their dry matter content. A subjective score ranging from 1 (wet, < 40 % DM) to 5 (dry, > 60 % DM) was used to assess the manure of each hen in three subsequent weeks. All data were recorded by the same person, one house per day. From all hens the full pedigree is known. Performance data include egg number, daily feed intake, egg weight, shell breaking strength and body weight. During the observation period the hens' age ranged from 41 to 46 weeks.

Fixed effects as house, tier and week of observation on the individual manure score and repeatability of the manure score were estimated for each strain with the procedure MIXED of the statistics program SAS.

Model 1:

$$Y_{ijklm} = \mu + HS_i + TR_j + RN_{kl} + a_l + e_{ijklm}$$

Y_{ijklm} = individual observation for each trait per record number_{kl} and animal_l

μ = overall mean

HS_i = fixed effect house_i

TR_j = fixed effect tier_j

RN_{kl} = fixed effect record number_{kl}

a_l = random effect animal_l

e_{ijklm} = random error

The average manure score per hen across the three observation weeks was used to study correlations with feed intake, body weight, egg production, egg weight and shell breaking strength.

Heritabilities and genetic correlations were estimated with the software package VCE 4 (GROENEVELD, 1998), using the following model 2:

Model 2:

$$Y_{ijklm} = \mu + HS_i + TR_j + a_k + e_{ijkl}$$

- Y_{ijkl} = individual observation for the corresponding trait per animal_k
- μ = overall mean
- HS_i = fixed effect house_i
- TR_j = fixed effect tier_j
- a_k = additive genetic effect animal_k
- e_{ijkl} = random error

Results and Discussion

The distribution of the recorded scores was concentrated on a dry matter content between 40 % and 60 % (scores 2, 3 and 4). Extremely wet or dry manure, with a dry matter content of less than 40 % or more than 60 %, were observed on less than 5 % of the hens. In the past PREISINGER *et al.* (1994) measured much lower and more wide spread dry matter contents for laying hens' manure. In his study the lowest dry matter content was on an average of 15 %, the highest with 65 % almost similar to this investigation and to results of STEFFENS *et al.* (2010). They published results from laboratory LUFA Nordwest obtained in 2008, where the dry matter content of laying hens' manure varied between 38 and 66 %.

The repeatabilities for the three weekly manure scores per hen were estimated with model 1 and are shown in table 1. With the exception of strain A, the house, tier and record number had a highly significant effect on the manure score. Within these three fixed effects the highest F-value and therefore the most important effect came up to the record number in three of the five tested strains, followed by the effect house. Only 766 hens belong to strain A, which were all housed in the same tier and therefore no effect was measurable. The repeatabilities were similar for all 5 strains, ranging from $\omega^2 = 0.21$ to 0.29.

Table 1: Repeatabilities (ω^2) and significance of fixed effects for the manure score.

strain	number of hens	ω^2	fixed effect	F-value	level of significance
A	766	0.21	house	74.9	***
			tier	-	-
			recording day	1.5	n.s.
B	2318	0.25	house	150.1	***
			tier	92.0	***
			recording day	252.6	***
C	1444	0.27	house	131.5	***
			tier	80.5	***
			recording day	219.7	***
D	2306	0.29	house	126.4	***
			tier	47.0	***
			recording day	467.7	***
E	2282	0.24	house	221.7	***
			tier	4.6	**
			recording day	202.6	***

The performance traits feed intake, body weight, egg number at peak production and egg weight had a highly significant influence on the average manure score per hen. Early egg production also had a significant effect, with an error probability of $p < 0.01$. No significant influence on the manure score could be found for shell breaking strength. The average manure score was lower for all strains in house 2, i.e. the droppings appeared wetter than in house 1. A negative trend in the dry matter content was additionally recorded from hens which were housed in the lowest tiers to the top tiers. The estimated Least-Squares-Mean score for manure consistency decreased from 3.1 to 2.8, which refer to more wet droppings in the upper than in the lower level. Differences between strains were found in this study as in a publication of LEENSTRA and PIT (1990). The analysis of variance showed that strain A had the driest, strain E the wettest manure.

The classified feed intake, body weight, egg number and egg weight also showed differences in the Least-Squares-Means for the average manure score per hen. Hens with a daily feed intake between 95g to 120g had the driest manure. A comparison of different body weight classes showed a negative relation to the average manure score. The higher the body weight, the lower the dry matter content. A desirable positive correlation was found between dryness of excreta and egg production, while larger eggs appeared to be associated with wetter manure.

With slight exceptions these described relations were confirmed by the estimated phenotypic and genetic correlations. Table 2 shows the genetic correlations between the performance traits and the manure score for each strain. Whereas the genetic correlation to the breaking strength highly varied from $r_g = +0.25$ to $r_g = -0.26$ between the analysed strains, the correlation to the traits feed intake, body weight, egg number at peak production and egg weight tend with exception of strain C always in the same direction. Therefore, the estimated genetic correlations not only confirm the results of the previous variance analysis, but also the conclusions of a study of LEENSTRA *et al.* (1992). Hens with dryer manure eat less feed, have a lower body weight, lay more eggs, especially at peak production and their eggs are smaller. Together with heritabilities that are in accordance to table 2 on a medium level for the manure score ($h^2 = 0.14$ to $h^2 = 0.36$), it is possible to consider the texture of manure in a selection program for layers.

Table 2: Heritabilities for manure score and conventional traits and their genetic correlations to manure score per strain.

trait	strain	A		B		C		D		E	
		h^2	r_g	h^2	r_g	h^2	r_g	h^2	r_g	h^2	r_g
manure score		0.14		0.36		0.25		0.24		0.22	
feed intake		0.30	-0.44	0.43	-0.50	0.21	+0.11	0.22	-0.21	0.19	-0.23
body weight		0.72	-0.10	0.71	-0.50	0.68	+0.01	0.60	-0.20	0.66	-0.23
egg number early		0.24	+0.74	0.41	+0.24	0.36	+0.00	0.47	-0.22	0.47	-0.10
peak rate of lay		0.18	+0.72	0.03	+0.04	0.10	-0.11	0.04	+0.13	0.02	+0.23
egg weight		0.68	-0.07	0.63	-0.33	0.53	+0.08	0.73	-0.14	0.66	-0.12
breaking strength		0.37	+0.002	0.29	-0.26	0.21	-0.06	0.30	+0.25	0.31	-0.02

Conclusion

Measuring the actual individual dry matter content of the droppings of large numbers of hens is not technically feasible in commercial breeding programs. Instead, subjective scoring of the dryness of weekly droppings from birds housed in single bird cages was investigated as an indicator trait for water content in the manure for individual hens. Estimated heritabilities in the range of 14 to 36 % for this trait suggest enough genetic variation within lines to expect response from selection, which would be a contribution to more environment friendly egg production. Hens with the desired performance profile, i.e. producing more eggs from less feed, apparently tend to produce drier excreta. With the addition of subjective scored manure-consistency in the selection index a significant sustainable contribution to a more environmental friendly egg production can be achieved.

Zusammenfassung

Kotkonsistenz als Selektionskriterium in der Legehennenzucht

Eine subjektive Kotbeurteilung von Leghennen in Einzelkäfigen ist als Merkmal zur Bestimmung des Wassergehaltes in Exkrementen geeignet. Die exakte Berechnung des tierspezifischen Trockensubstanzgehaltes im Legehennenkot ist hingegen zu aufwendig, um die Kotkonsistenz in ein Zuchtprogramm zu etablieren.

Für die subjektive Beurteilungsnote des Kotes wurden Heritabilitäten von 14 bis 36 % geschätzt. Diese versprechen genügend genetische Varianz innerhalb der Linien, für eine erfolgreiche Selektion auf den Trockensubstanzgehalt im Hühnerkot. Wünschenswerte genetische Korrelationen zu weiteren wichtigen Selektionsmerkmalen, wie der Futteraufnahme und der Eizahl, sowie ein relativ geringer Aufwand für die Datenerfassung unterstützen die Einbeziehung dieses Merkmals in den Selektionsindex. Die subjektive Kotbeurteilung liefert einen nachhaltigen Beitrag zu einer umweltfreundlicheren Eierproduktion.

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Genetic evaluation of pure-line and cross-line performance in layers

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Introduction

Crossbreeding is a standard practice in poultry breeding programmes as a way of exploiting heterosis. However, there is no consensus on the most effective way to maximize the genetic response in cross-bred commercial animals (Besbes and Ducrocq, 2003). Furthermore, the goal of breeding is not to maximise heterosis, but to maximise overall profitability in the commercial cross, the parents and the pure lines (Flock *et al.*, 1991). Environmental differences exist between breeding farms (e.g. with single cages) and commercial farms. Thus, both environments should be taken into account in the breeding program, to minimise possible genotype-environment-interactions that can reduce the response to selection on the commercial level. Considering cross-bred and pure-bred performance as two separate, but correlated traits offers an elegant way to take these environmental effects into account. The cross-bred performance is captured in the environment in which the breeding goal is defined (Wei and van der Werf, 1995). In order to optimise a breeding program, ranking based on pure-bred performance has to be compared with ranking based on cross-bred performance on commercial farms. If there are significant differences, cross-bred information has to be included in the selection process.

The aim of this study was to estimate genetic correlations between pure-bred and cross-bred performance in commercial white-egg and brown-egg lines as essential information to optimise the breeding programs.

Material and methods

The pure-line data used for the present analysis represent three generations of a White Leghorn (WL) and a Rhode Island Red (RIR) male line, recorded in breeding farms with single cages and high standards of bio-security, feed quality and environment control. The single-cross daughters of the same sires were housed in group cages (4 hens per cage) in four commercial farms each generation, two farms for each cross. The cross-bred hens had only sire pedigree. On average, about 70 sires per line and generation were used to produce 50 WL and 69 RIR pure-bred daughters and 30 cross-bred daughters per line and generation.

The traits used for this study were cumulative early egg production between 20 and 27 weeks of age (P1), peak production between 28 and 47 weeks of age (P2) and late egg production between 48 and 68 weeks of age (P3). Average egg weight was measured at 29, 34 and 45 weeks of age (EW). Furthermore, the average shell breaking strength (SS) was measured at 40, 43 and 46 weeks of age. Shell colour (SC) was measured at 30 and 45 weeks of age and averaged. Mortality was taken into account for egg production in group cages, dividing production per cage by the number of hens alive in each period. In the cross line egg quality traits (EW, SS and SC) were recorded at one day's production, and cage means were calculated from individual measurements. Only cages with 4 hens at the beginning of production were included in this study to avoid heterogeneity of residual variance of multiple bird cage data due to different group size.

A total of 10,002 and 13,367 pure-bred records and 1,426 and 1,394 cage averages for the WL and RIR cross-breds were included in the statistical analysis. Table 1 shows an overview of the general statistics for the different traits.

The program VCE 4 (Neumaier and Groeneveld, 1998) based on the REML method and a multiple trait animal model was used to estimate (co)variance components, with the model:

$$y_{ijk} = \mu + \text{GHHT}_i + a_j + e_{ijk}$$

where y_{ijk} is the vector of observations for the different traits; μ is the population mean; GHHT_i is the combined fixed effect of generation, house, hatch and tier; a_j is the random additive genetic effect of

Table 1: Means and standard deviations for the traits studied

Trait	White Leghorn				Rhode Island Red			
	Pure-line		Cross-line		Pure-line		Cross-line	
	Mean	s	Mean	s	Mean	s	Mean	s
P1 (%)	66.1	16.1	82.8	7.4	69.8	18.8	77.6	11.4
P2 (%)	96.0	4.3	94.4	5.5	94.5	5.2	91.4	8.0
P3 (%)	92.5	7.3	90.0	7.6	87.4	9.0	85.6	10.2
EW (g)	60.1	3.4	62.6	2.3	61.9	4.2	64.9	2.6
SS (N)	47.6	5.8	48.6	6.3	46.7	6.4	50.8	6.9
SC	85.5	3.7	88.6	2.2	12.0	8.4	14.3	5.9

animal j ; and e_{ijk} is the random residual effect. In the case of the cross-line data for laying rate, only a cage average could be measured and only the sire was known. Therefore, in the model the cage mean was used as vector of observations, and only one hen out of the half-sib family cage was used for the animal effect.

Theoretically, the residual variance estimated from pooled observations should be about n times the estimate based on individual observations (Biscarini et al., 2008). According to this author, the heritability for pooled data should be recalculated as: $h^2 = \sigma_a^2 / (\sigma_a^2 + n \sigma_e^2)$; where 'n' is the number of hens/cage (4 in this case). This is in line with Simianer and Gjerde (1991) who explained that estimation based on group means contains less information on the group variation, which essentially contributes to the estimation of residual variance components.

Results and discussion

Table 1 shows the means for all traits included in the analysis. Most people would expect higher performance in single crosses than in the pure-breds due to heterosis, but as shown in the table this is not always the case. It should be borne in mind that the pure-lines were kept under optimal bio-security and management conditions, whereas the cross-breds were kept under less ideal commercial environment in multiple-bird cages.

Table 2 shows the heritabilities and genetic correlations. Early egg production (P1) had the highest heritability, which is explained by variation in age at sexual maturity (Preisinger and Savas, 1997). The heritability was lowest during peak production and increased again towards the end of lay, confirming estimates from the literature (e.g. Anang *et al.*, 2000). No or a slightly negative correlation was found between the production at sexual maturity and at the end of lay. As expected, the genetic correlation was high between peak production and persistency.

The heritabilities were consistently higher based on full pedigree pure-line records from single cages than based on the cross-line data from commercial multiple bird cages. The genetic correlations between pure-bred and cross-bred performances were moderate to high at sexual maturity ($r_g = 0.63$ and 0.83), whereas the correlations decreased to moderate to low levels in the other two stages of production (r_g between 0.1 and 0.5). The heritabilities obtained in this study were similar to those published by Nurgartiningasih *et al.* (2004).

Estimates of genetic parameters for egg quality traits are summarized in table 3. For the cross-breds, the individual egg quality measurements were used. Additionally, cage averages were assigned to one of the hens in the cage and used for the analysis to underline the problems of using these traits as a cage average. The heritability estimates based on cage averages are obviously too high and reflect the reduced residual variance when using cage averages. Using the single egg records, the heritability estimates are slightly lower than in the pure-breds, which would be expected under "sub-optimal" conditions. It should also be noted that only one egg per hen was evaluated for group cages, whereas several eggs per hen were evaluated for the pure-lines in single cages.

