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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.

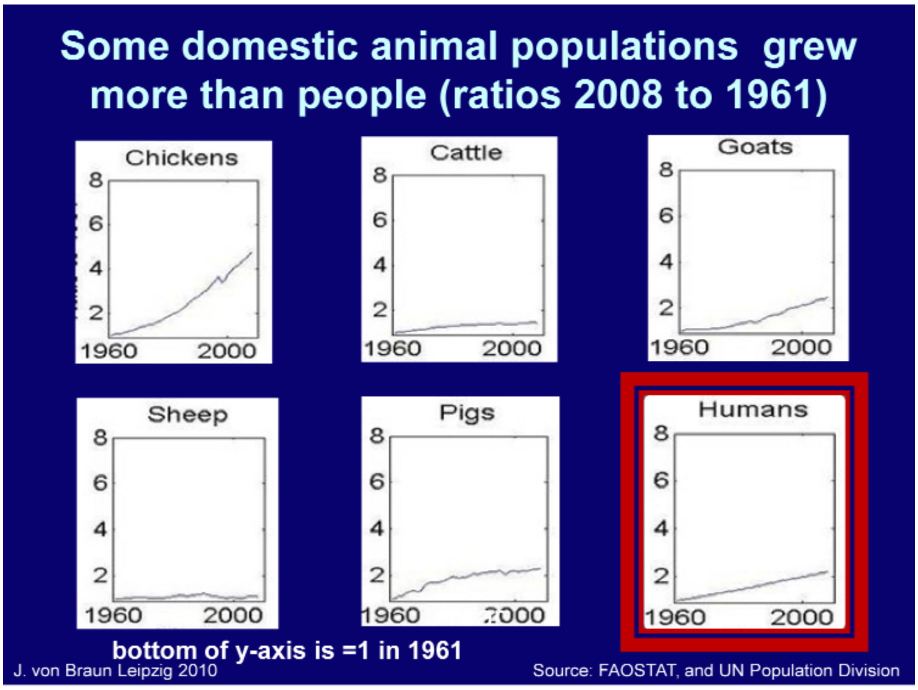
This presentation will cover population concerns and food insecurity; production and income issues; consumption; health and nutrition; environment, and the required policy action. As this is a rather wide-ranging set of issues I offer you my two main conclusions:

- 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).

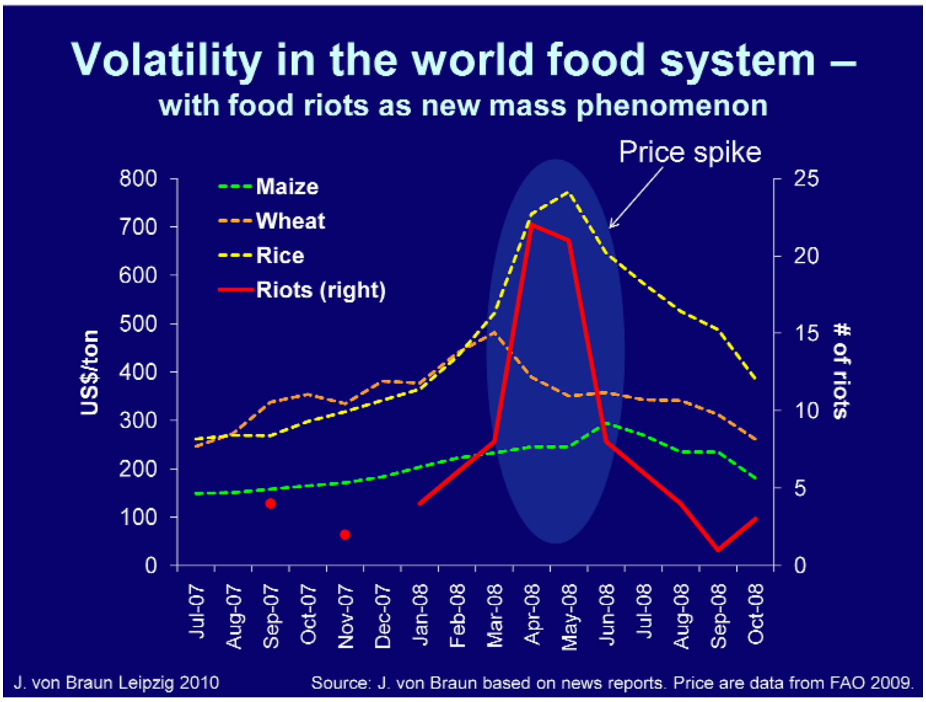


* Keynote address at the 9th World Congress on Genetics Applied to Livestock Production, Leipzig, Germany, August 1, 2010

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.



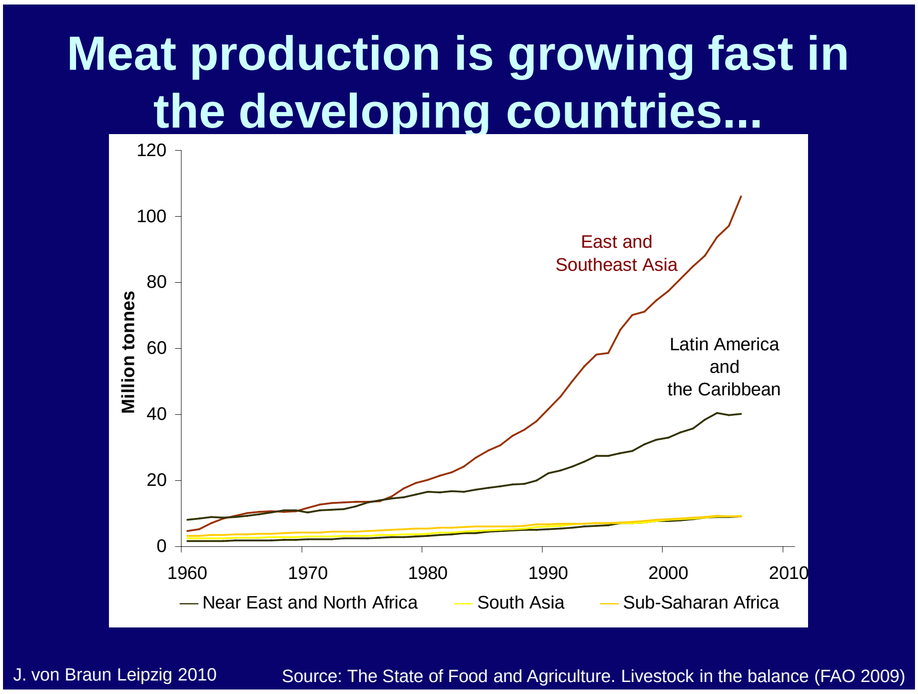
The price spikes of 2008 are well remembered in the animal production community. People suffered but also livestock producers suffered because feed was becoming so expensive. The food crisis multiplied the number of poor and hungry people in low income countries. But something in addition happened: as 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.

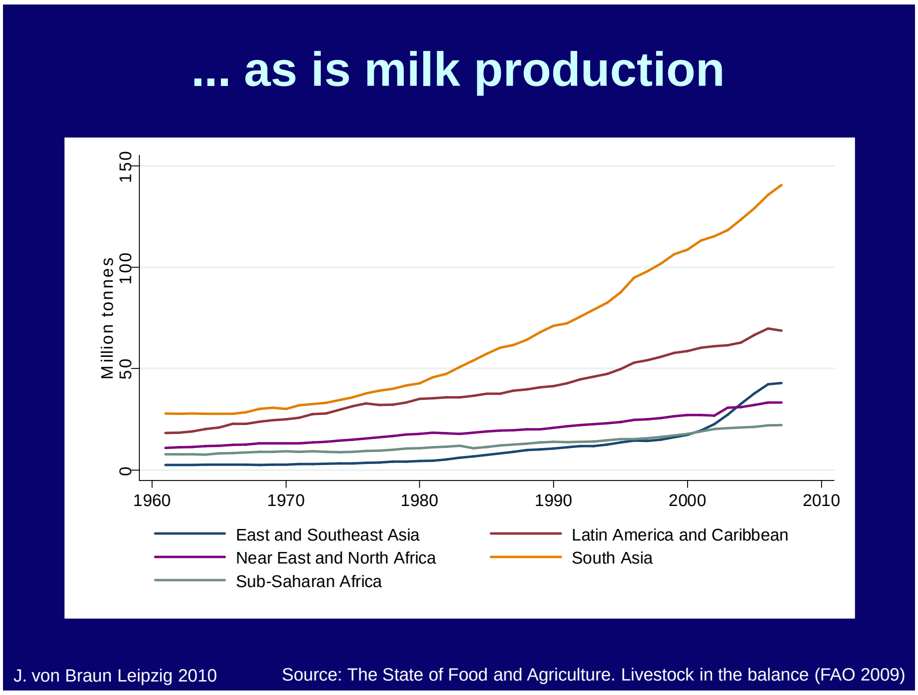
Production

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.

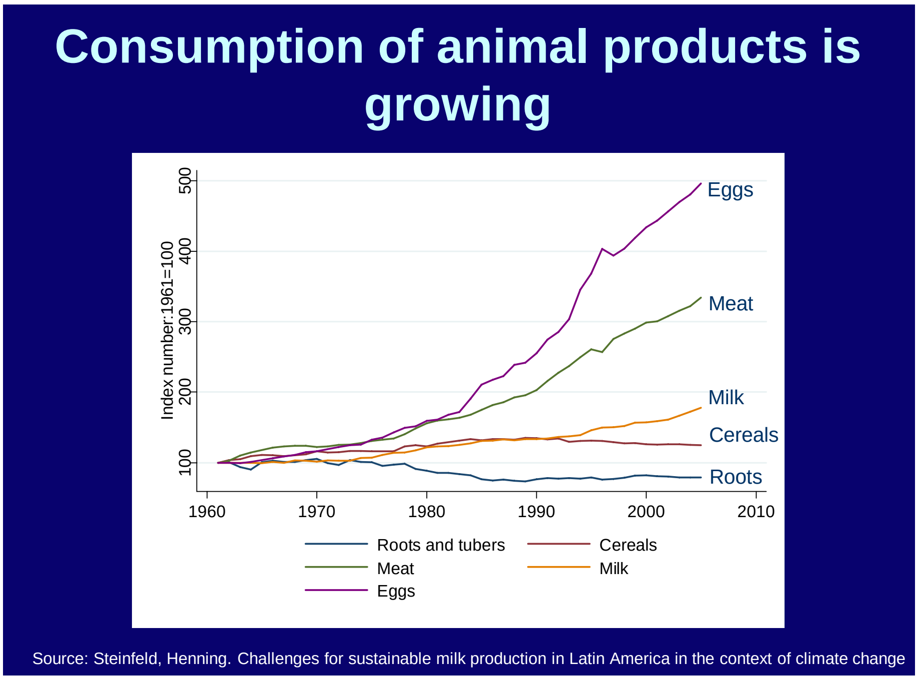
Consumer reaction to increasing meat prices is generally strong. A recent review looking across more than 400 studies of the price elasticity of meat shows that a 1% increase in prices presses meat demand down by 0.5 %. That's a very important issue to keep in mind because pricing and taxation of meat 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.

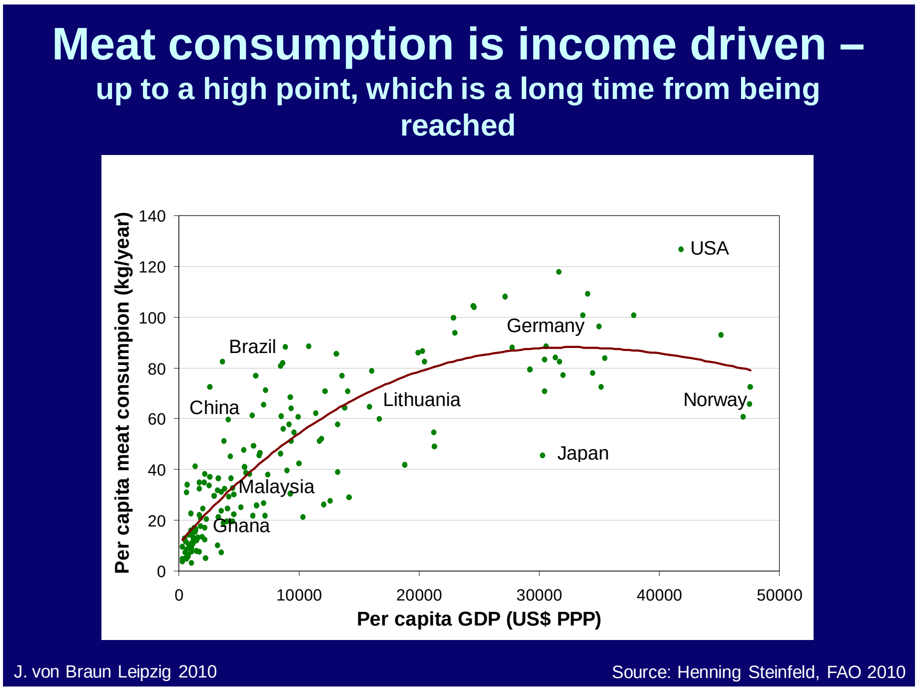
Taste

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





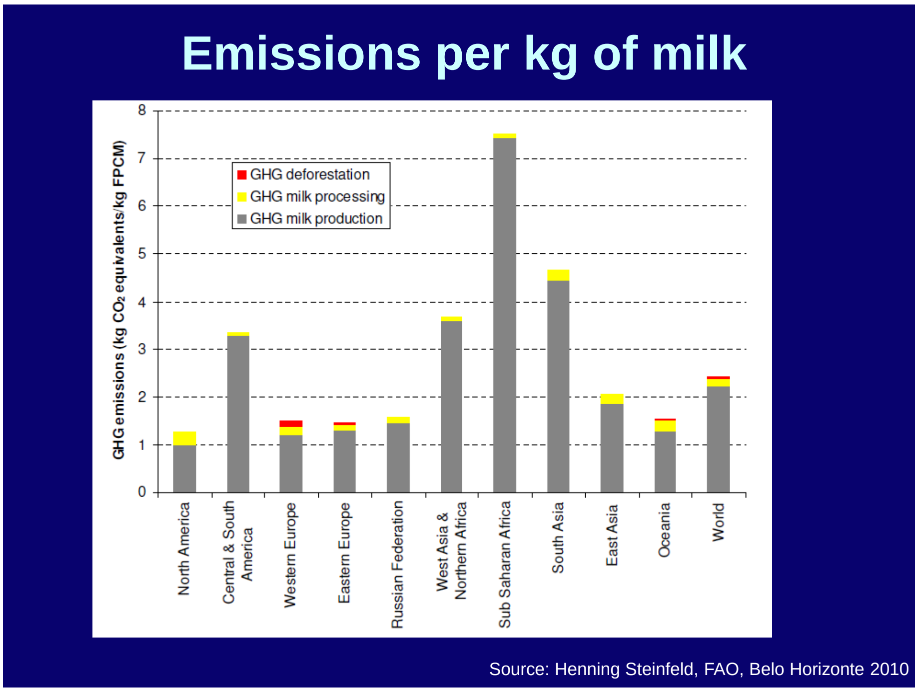
People´s and Animal's Health

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 Futterverwertung 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:

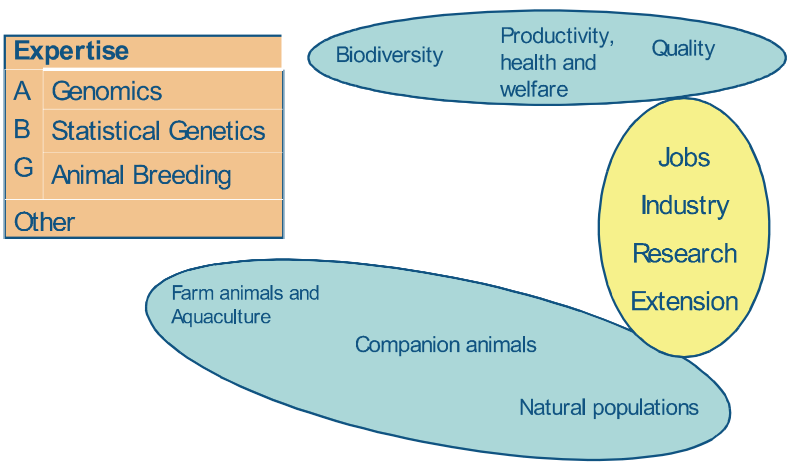
1. increase of livestock and fish production, while preserving the quality of the products and the welfare of animals;
2. development of sustainable animal breeding programmes that contribute to improved livelihood of farmers and efficient food chains;
3. development of sustainable breeding programmes 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

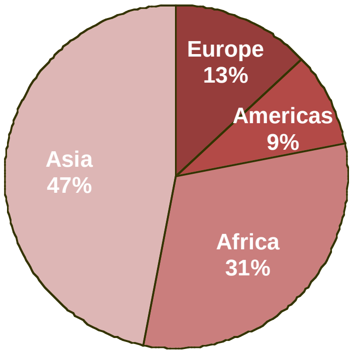
Participation

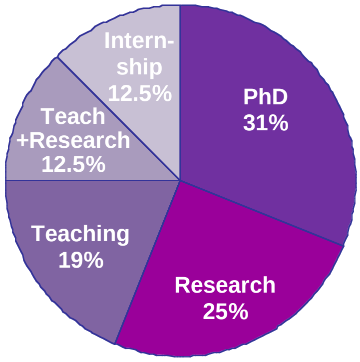
In the first year, we received 240 applications. After the selection procedure, 24 students started the program in August 2007. In subsequent years, the number of applications increased to over 300 in 2010. The number of students that started the program has varied between 22 and 25. The students originate 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 (NH_3) 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 NH_3 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:

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

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 $number_k$
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 ω^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 tier recording day	74.9 - 1.5	*** - n.s.
B	2318	0.25	house tier recording day	150.1 92.0 252.6	*** *** ***
C	1444	0.27	house tier recording day	131.5 80.5 219.7	*** *** ***
D	2306	0.29	house tier recording day	126.4 47.0 467.7	*** *** ***
E	2282	0.24	house tier recording day	221.7 4.6 202.6	*** ** ***

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.

strain	A		B		C		D		E	
trait	h²	rg	h²	rg	h²	rg	h²	rg	h²	rg
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:

$$y_{ijk} = \mu + GHHT_i + a_j + e_{ijk}$$

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 Nurgiartiningsih *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.

Table 2: Genetic Parameters for egg production traits in pure-line and cross-line (cross-line data as cage average, WL in the first row and RIR in the second)

Pure-line (breeding farm - single cages)			**Cross-line** (commercial farm - group cages)		
P1	**P2**	**P3**	**P1**	**P2**	**P3**
0.40 **0.37**	0.31 0.15	0.07 0.02	0.63 0.83	0.44 -0.29	0.14 -0.32
	0.13 **0.24**	0.75 0.83	-0.10 0.34	0.50 0.10	0.33 0.05
		0.17 **0.30**	-0.20 0.26	0.30 0.26	0.27 0.33
			0.36 **0.16**	0.40 0.11	-0.06 -0.10
				0.03 **0.04**	0.55 0.63
					0.06 **0.07**

Estimates of genetic parameters for egg quality traits are summarized in table 3. For the cross-breds, the individual egg quality measurements was used. Additionally, cage averages were assigned to one of the hens in the cage and used for the analysis to underline the problem of using these traits as cage averages. 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.

Table 3: Genetic Parameters for egg quality traits in pure-lines and cross-lines, with cross-bred data as cage average and as individual records

			Cage average		**Individual records**	
		h^2 pure-line	h^2 cross-line	r_g	h^2 cross-line	r_g
EW	WL	0.67	0.95	0.93	0.66	0.90
	RIR	0.64	0.99	0.84	0.59	0.73
SS	WL	0.38	0.25	0.85	0.32	0.84
	RIR	0.43	0.18	0.83	0.29	0.73
SC	WL	0.70	0.92	0.83	0.53	0.82
	RIR	0.49	0.96	0.89	0.61	0.88

Wei *et al.* (1995) concluded that combined cross-bred and pure-bred selection should be better than selection based only on pure-line performance when improvement of cross-bred performance is the goal. This strategy is generally more efficient when genetic correlations are below 0.8, which is the case for laying rate. However, it is essential to find suitable farms with reliable data recording and flexible housing schedules to match well-designed tests to augment the basis for selection focused on the needs of the egg industry. If the residual variance is high due to uncontrolled factors which are not representative for other farms, the heritability will be low and the gain from using this information questionable.

Conclusions

The results of this study indicate that the genetic correlation between pure-line and cross-line egg production was moderate, whereas the genetic correlations for all egg quality traits were high. This confirms the working hypothesis that egg production data of cross-line relatives collected under commercial conditions can contribute significantly to genetic improvement, while selection for egg quality traits can be limited to pure-line records. The loss of statistical information on individual variation due to working with cage mean is inevitable, but group cage data of cross-lines can help to reduce the effect of genotype-environment interaction while taking heterosis effects into account. The parameter estimates found in this study confirm that combined pure-line and cross-line selection is an efficient approach to improve total genetic merit under field conditions.

Zusammenfassung

Genetische Parameter von Reinzucht- und Kreuzungsleistungen bei Legehennen

Mit einem Mehrmerkmals - Tiermodel wurden genetische Parameter für Reinzucht- und Kreuzungsleistungen geschätzt. Die Daten wurden über drei Generationen von zwei kommerziellen Reinzuchtlinien in Einzelkäfigen und Kreuzungsnachkommen derselben Väter in Gruppenkäfigen erfasst.

Die Heritabilitäten für Legeleistung liegen im Bereich von h^2=0,03 bis 0,40). Die genetischen Korrelationen zwischen Reinzucht- und Kreuzungsleistung nehmen im Verlauf der Produktion von anfangs r_g= +0,63 bis +0,83 auf r_g= +0,10 bis +0,50 ab und unterstreichen damit die Notwendigkeit, unter praxisnahen Bedingungen auf Persistenz der Legeleistung zu testen. Die untersuchten Eiqualitätsmerkmale haben in beiden Umwelten eine mittlere bis hohe Heritabilität und durchweg hohe genetische Korrelationen zwischen Reinzucht- und Kreuzungsleistung.

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Development of a third generation vaccine to prevent *Salmonella* infections in commercial poultry flocks

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Introduction

Even after more than a decade of combating *Salmonella* infections, this organism still represents an important cause of human disease (EFSA, 2009, Newell *et al.*, 2010). Recent studies estimate 80.3 million annual cases of food-borne disease related to *Salmonella* worldwide (Majowicz *et al.*, 2010). Within the European Union *Salmonella* is the second most important cause of food-borne infections (EFSA, 2007) with Salmonella Enteriditis still representing the most commonly isolated *Salmonella* serovar in human salmonellosis (EFSA, 2007; WHO, 2006). Even today contaminated eggs from infected layers remain the major source of *Salmonella* Enteriditis infection (Delmas *et al.*, 2006; EFSA, 2007; Korsgaard *et al.*, 2009; Stevens *et al.*, 2009). As a consequence all member states of the European Union have to implement Regulation EC No. 2160 from 2003 on a national basis in order to control *Salmonella* and other zoonotic agents of significance for public health in farm animals. The prevention of *Salmonella* infections in laying hens and the control of the pathogen at farm level is the key to producing safe egg products and to being in line with Regulation EC No. 2160/2003. As described recently by Carrique-Mas and Davies (2008) the member states of the EU have to invest more in the prevention, detection and control of Salmonella infections in laying hens.

Vaccination plays an important role in the overall biosecurity system on chicken farms to prevent *Salmonella* infections (Temelli *et al.*, 2010). When vaccination first arose as a method of combating this organism, inactivated vaccines were developed by various companies. Due to many reasons, such as ease of application, animal welfare, and especially efficacy, attenuated live vaccines entered the market with great success a short time later. These live, attenuated vaccines were homologous vaccines against either *Salmonella* Enteritidis or *Salmonella* Typhimurium. Scientific evidence shows that serovar overlapping effects exist, but homologous vaccines offer the best protection against infection (Springer *et al.*, 2000; Martin *et al.*, 1996; Chacana *et al.*, 2006).

In this paper results on the safety and efficacy of a new combined homologous vaccine against *Salmonella* Enteritidis and *Salmonella* Typhimurium (Lohmann testing vaccine) are discussed.

Safety of the vaccine

The Lohmann testing vaccine is safe for day-old Specific Pathogen Free (SPF) chicks, the most susceptible chickens for infection with *Salmonella*, when administered with a single, repeated or 10-fold dose. The dissemination of the vaccine strains is limited and the strains do not persist in internal organs for a long period of time. The vaccine is also not transmitted on or into the eggs in vaccinated birds.

Safety trials with day-old Peking ducklings showed that oral application of the vaccine is completely safe to use. The Lohmann testing vaccine also represents no health hazard to turkeys or any other tested species (Lohmann Animal Health, data on file).

Oral application via drinking water of the Lohmann testing vaccine to 25.000 day-old commercial layers under field conditions was proven to be safe. Repeated vaccination on day one, week 6 and week 16 of life was observed under field conditions and no safety issues caused by the vaccination were observed (Table 1).

Table 1: Safety of repeated oral application of the Lohmann testing vaccine under field conditions in two flocks, each with 12.500 commercial layers (Hy-Line Brown) (Lohmann Animal Health, data on file)

Mortality rate	not affected
Dissemination into organs (liver, bile, caecum, tonsils, ovary)	no positive findings
Disseminations to eggs	no positive findings
Spread to humans	no positive findings
Egg production	not affected
Spread to environmental samples including birds and other animals	no positive findings

Table 2: Vaccination scheme

Group	1st day of life	6th week of life	16th week of life
A	min. dose of Lohmann testing vaccine, orally	min. dose of Lohmann testing vaccine, orally	min. dose of Lohmann testing vaccine, orally
B	AviPro® Salmonella Vac E, orally	AviPro® Salmonella Vac E, orally	AviPro® Salmonella Vac E, orally
C	AviPro® Salmonella Vac T, orally	AviPro® Salmonella Vac T, orally	AviPro® Salmonella Vac T, orally
Unvaccinated control	-	-	-

Efficacy and duration of immunity

An optimum vaccine should protect against *Salmonella* infection throughout the laying period. In order to test efficacy of the immune response at the beginning and at the end of the laying period, SPF (Lohmann Selected Leghorn) birds were vaccinated orally either with a minimum dose of the Lohmann testing vaccine, AviPro® Salmonella Vac E or AviPro® Salmonella Vac T on the first day of life, in week 6 and in week 16 (Table 2). Vaccinated birds were kept throughout the laying period.

At the beginning of production (week 21 or 22 of life) birds from each group were challenged orally with either 2 x 10^9 cfu of *Salmonella* Enteritidis Nal^{res} or 3 x 10^9 cfu of *Salmonella* Typhimurium K284/93 Nal^{res} per bird. Seven days post challenge the caeca and liver of all birds were investigated bacteriologically for the presence of the challenge strain. The liver and caeca of the chickens vaccinated with either the monovalent vaccines (AviPro® Salmonella Vac E (Figure 1) or AviPro® Salmonella Vac T (Figure 2)) or Lohmann Testing Vaccine showed a reduction in their colonisation by the *Salmonella* field strains as compared to unvaccinated chickens.

At an age of 68 weeks 10 birds were challenged with 2 x 10^9 cfu of *Salmonella* Enteritidis Nal^{res} per bird and analysed in comparison to an unvaccinated, challenged control group of the same hatch that was kept under the same conditions. Seven days post challenge the caeca and liver of all birds were examined bacteriologically for the presence of the challenge strain. The unvaccinated control birds had diarrhoea starting 4 days post challenge. The vaccinated birds showed no clinical signs. Bacteriological analysis revealed that the titre of the virulent strain *Salmonella* Enteritidis Nal^{res} was significantly reduced in the liver and caeca of vaccinated birds as compared to organs of unvaccinated control birds (Figure 3). Persistence of the challenge strain in the liver was completely inhibited in the vaccinated birds.

Figure 1: Persistence of the challenge strain *Salmonella* Enteritidis Nal^{res} in internal organs 7 days post infection in week 21

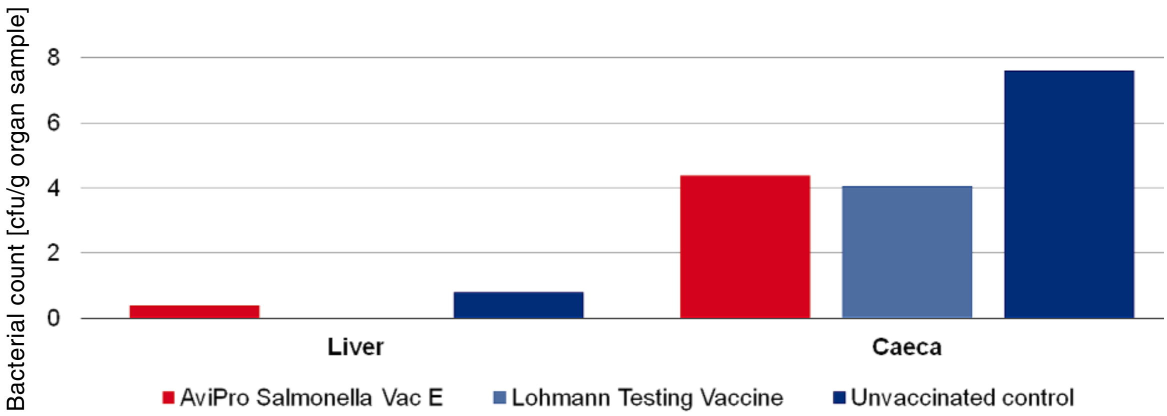


Figure 2: Persistence of the challenge strain *Salmonella* Typhimurium K284/93 Nal^{res} in internal organs 7 days post infection in week 22

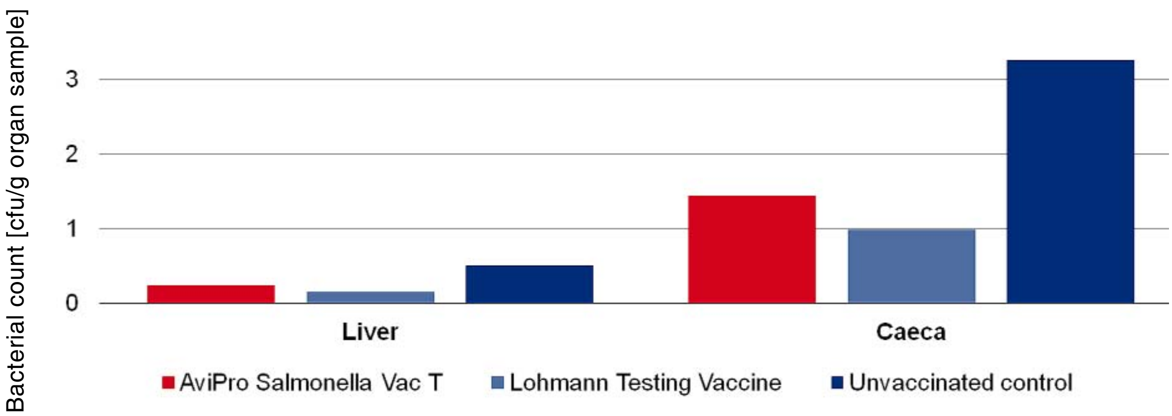


Figure 3: Persistence of the challenge strain *Salmonella* Enteritidis Nal^{res} in internal organs 7 days post infection in week 68

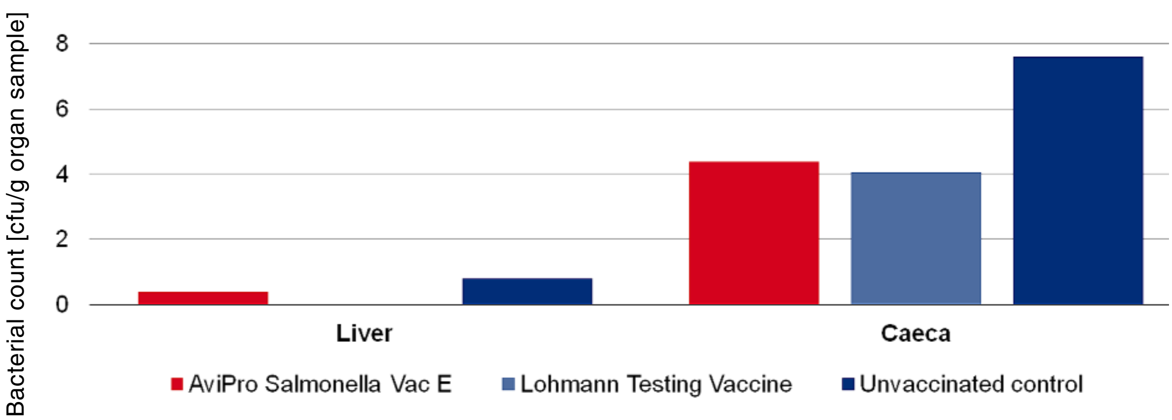
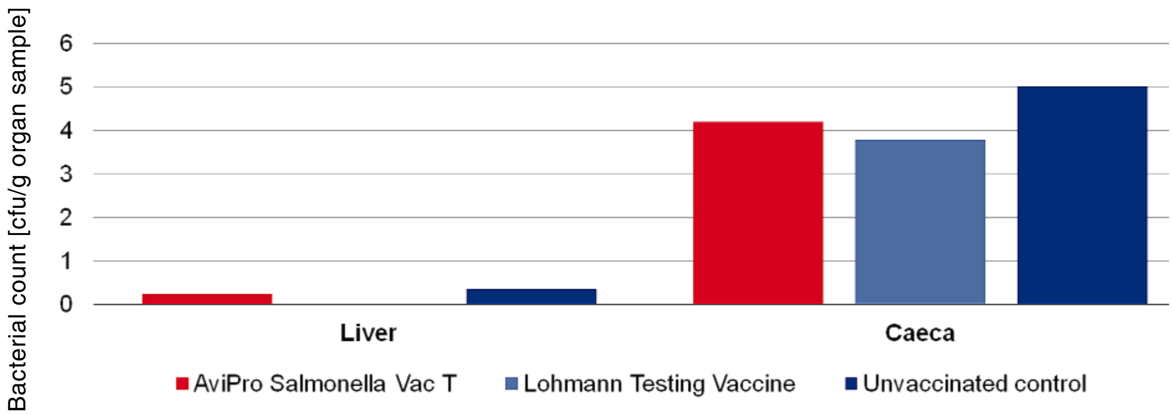


Figure 4: Persistence of the challenge strain *Salmonella* Typhimurium K284/93 Nal^{res} in internal organs 7 days post infection in week 62



In order to determine the protection against infection with *Salmonella* Typhimurium 10 birds were challenged with 3 x 10^9 cfu of Salmonella Typhimurium K284/93 Nal^{res} per bird and compared with birds from the unvaccinated, challenged control group. Seven days post challenge infection the liver and caeca of the vaccinated birds contained significantly less of the challenge strain than the unvaccinated control birds (Figure 4).

Diagnostics

According to the European regulations (EC No. 213/2009 and EC No. 1168/2006) samples taken from layer and breeder flocks are supposed to be tested for the presence of *Salmonella* by following EN ISO 6579:2002. This method includes the use of modified semi-solid Rappaport-Vassiladis medium (MSRV) as selective growth medium. Since growth of both *Salmonella* strains of the Lohmann testing vaccine is rather poor on this medium, this method cannot be recommended for the determination of the presence of the vaccine strains. Both strains can be detected as described previously in the literature (Schröder *et al.*, 2004). In addition the AviPro® Plate, a susceptibility microdilution test, allows for a standardized test to detect and differentiate between the vaccine strain and *Salmonella* field strains.

Conclusion

The Lohmann testing vaccine was proven to be safe and efficacious after challenge with high doses of *Salmonella* Enteritidis as well as *Salmonella* Typhimurium, the most common *Salmonella* serovars in poultry. Therefore, this new vaccine represents a new potent tool in the prevention of *Salmonella* infections in poultry flocks and contributes highly towards establishing consumer confidence in safe poultry products. The novel and unique combination of two live *Salmonella* strains in one vaccine add to the development of user-friendly products in *Salmonella* prevention at farm level. In general, vaccination alone cannot keep flocks free of Salmonella. Only a combination of high standards in biosecurity and hygiene as well as proper vaccination with homologous vaccines can protect poultry flocks against infection with Salmonella Enteritidis and *Salmonella* Typhimurium.

Summary

Salmonella is one of the major sources of food-borne disease in humans. Contaminated eggs still cause high numbers of cases of human salmonellosis. Vaccination of poultry flocks against *Salmonella* Enteritidis and *Salmonella* Typhimurium is an important part of the biosecurity and hygiene programs to prevent infection in the first place. The new combined homologous vaccine tested in this study was proven to be safe and efficacious after challenge infection with virulent strains of both serovars.

Zusammenfassung

Salmonellen sind eine der Hauptursachen von Lebensmittel-bedingten Erkrankungen beim Menschen. Noch immer sind kontaminierte Eier die Ursache für eine Vielzahl von Salmonellosen. Die Impfung von Geflügelbeständen gegen Salmonella Enteritidis und Salmonella Typhimurium ist ein wichtiger Bestandteil der Hygiene- und Biosicherheitsmaßnahmen, um eine Infektion in den Beständen zu vermeiden. Der im Rahmen dieser Untersuchungen getestete homologe Kombinationsimpfstoff war absolut unbedenklich und wirksam nach einer Belastungsinfektion mit virulenten Stämmen beider Serovare.

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Epidemiological relationship between *Salmonella* Infantis isolates of human and broiler origin

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Introduction

Salmonella spp. are considered to be one of the most common causes of food borne bacterial infections. According to WHO estimates, *Salmonella* (*S.*) is responsible for 3 million infections of humans annually (Crump *et al.* 2004). In Germany 31.185 *Salmonella* infections were reported to the Robert Koch-Institute in 2009. Since the aetiology of enteric infections in many cases is not established and only a fraction of the cases is notified, it is assumed that actually about one million people are infected annually in Germany (Tschäpe & Bockemühl 2002).

The host-unspecific serovar S. Infantis ranks first among the top ten human isolates of *S. enterica* in Germany and Europe since 2001 (Galanis *et al.* 2006). Since the late 1970s this serovar has been increasingly recorded worldwide in countries like Argentina, Australia, Brazil, The Netherlands, Finland, Canada, Hungary, Japan, New Zealand and Russia. *S.* Infantis is also observed in hospitals, where primarily small children are infected, but also adults, sometimes with septicaemic symptoms and lethal outcome (Hasenson *et al.* 1995). Of special importance is that *S.* Infantis infections may persist in hospitals over a long period of time (Pessoa-Silva *et al.* 2002; Fonseca *et al.* 2006).

The reservoir for *S.* Infantis salmonellosis in humans is primarily seen in animal and especially poultry populations. A survey of the European Food Safety Authority (EFSA) indicates that *S.* Enteritidis and *S.* Infantis were mainly found in layer and broiler farms in Europe (Table 1). The highest frequency of serovar *S.* Infantis in broilers was found in Hungary (87 %), followed by Poland (19 %) and the Czech Republic (13 %) (EFSA 2007a; 2007b). In Germany the occurrence of *S.* Infantis was 3.9 % in layer flocks and 8.9 % in broiler flocks (BfR 2005, 2006; Table 1).

Table 1: Results from EFSA and BfR studies on occurrence of *Salmonella* spp. in laying and broiler farms (EFSA 2007a, 2007b; BfR 2005, 2006)

layers				broilers			
EU-wide 2007		Germany 2005		EU-wide 2007		Germany 2006	
S. Enteritidis	52.3 %	*S.* Enteritidis	64.4 %	*S.* Enteritidis	3.8 %	*S.* 4, 12:d:-	23.0 %
S. Infantis	8.4 %	*S.* ssp. I R.*	18.4 %	*S.* Infantis	22.0 %	*S.* Paratyphi B	15.6 %
S. Typhimurium	4.8 %	*S.* Typhimurium	5.1 %	*S.* Mbandaka	8.1 %	*S.* Anatum	14.7 %
S. Mbandaka	4.1 %	*S.* Infantis	3.9 %	*S.* Hadar	3.7 %	*S.* Infantis	8.9 %
S. Livingstone	2.7 %	*S.* Livingstone	1.8 %	*S.* Typhimurium	3.0 %	*S.* Typhimurium	8.4 %

* I R., rough form

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Another study by EFSA on the prevalence of *Salmonella* in broiler meat showed that *S.* Infantis was the most frequent serovar in the EU, averaging 55 %. In some countries as Hungary (96 %), Slovenia (55 %) and Austria (44 %) it was the most important serovar (EFSA 2007c). With an incidence of 7 % and 10 % respectively in Europe and Germany, *S.* Infantis ranked second in eggs and egg products (EFSA 2009).

The persistence of *S.* Infantis in broiler flocks is not only a problem in Hungary, but also in Japan, Iceland, France, The Netherlands, USA, Australia, Turkey, Saudi-Arabia and Algeria (Ai-Nakhli *et al.* 1999; Van Duijkeren *et al.* 2002; Sexton *et al.* 2007; Thorsteinsdottir *et al.* 2007; Cetinkaya *et al.* 2008; Elgroud *et al.* 2008; Heithoff *et al.* 2008; Rivoal *et al.* 2009).

In Germany and several other countries live vaccines against *S.* Enteritidis and *S.* Typhimurium are in use. It can be assumed that live vaccination with *S.* Enteritidis will introduce immunity against *Salmonella* of group 0:9 (D_1) and live vaccination with *S.* Typhimurium immunity against *Salmonella* of group 0:4 (B). After successful control of *S.* Enteritidis and *S.* Typhimurium apparently other serovars may enter this ecological niche and persist. It is known that *S.* Enteritidis entered poultry facilities after serovar *S.* Gallinarum had been eliminated (Rabsch *et al.* 2000).

S. Infantis of group 0:7 (C_1) is a potential candidate for a change of serovars and so far there is no licensed vaccine against *S.* Infantis. In Hungary and Japan *S.* Infantis is already the most frequent serovar in broilers, which is mirrored by an increase of human isolates in these countries (Nogrady *et al.* 2008; Shahada *et al.* 2008; Ishihara *et al.* 2009; Noda *et al.* 2010).

Suitable techniques for typing serovars are required to monitor sources and routes of infections. A method requiring relative little laboratory equipment is phage typing, which uses specific bacteriophages to differentiate strains belonging to the same serovar. Using established phage typing systems for *S.* Typhimurium, *S.* Enteritidis and *S.* Agona it has been possible to document the pathways of infections (Ward *et al.* 1987; Rabsch *et al.* 2005; Rabsch 2007). Advantages of phage typing are speed and low cost, but this method requires special expertise to interpret the phage types and strict quality control of the biological reagents (Schwarz *et al.* 2003).

Material und Methods

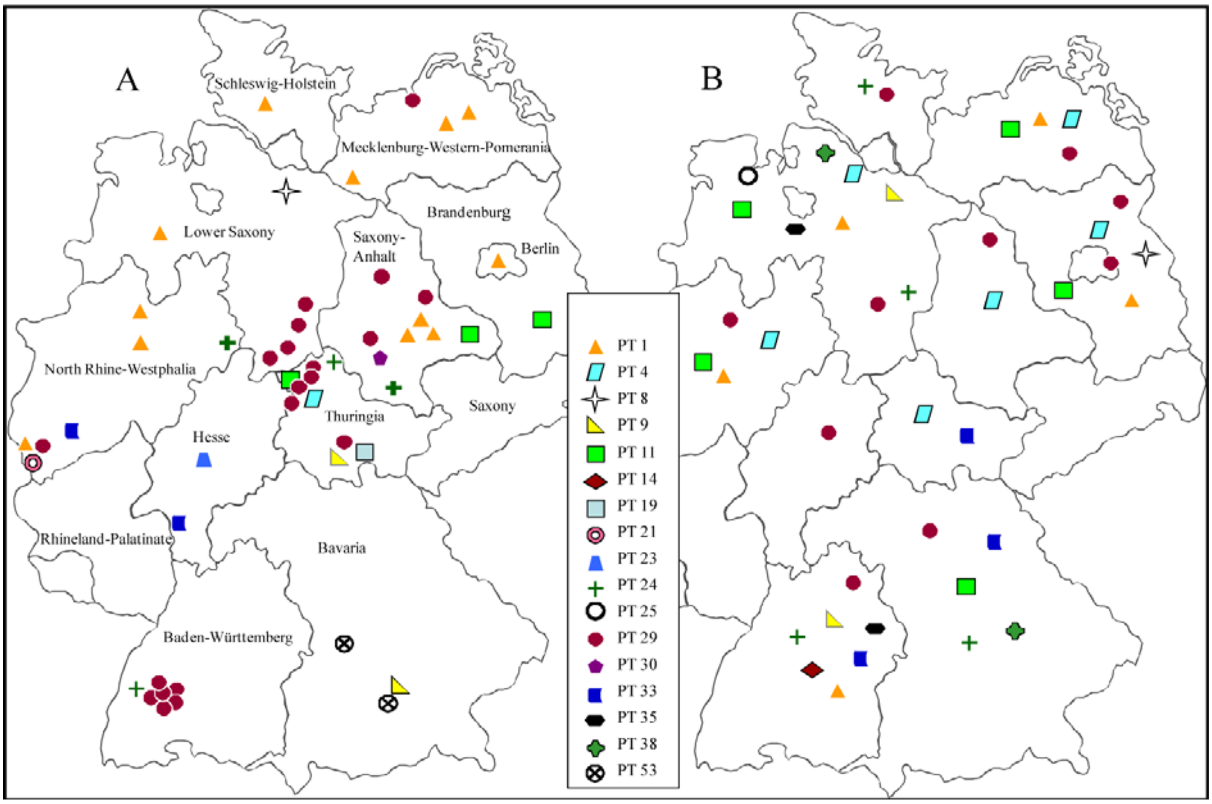
In order to monitor the serovar *S.* Infantis more effectively, a new phage typing system was established at the National Reference Center for Salmonella and other Enteric Pathogens (NRC) of the Robert-Koch-Institute. The phage typing follows the standardized NRC-protocol (Rabsch 2007). A total of 617 *S.* Infantis strains from Germany (n=542), Hungary (n=25), Iceland (n=21), and Australia (n=29) were included in this study and investigated by phage typing. The strains were isolated from outbreaks and sporadic cases of gastroenteritis in humans, from animals, food, feed and the environment during the period 2002 - 2009. For molecular subdifferentiation and examination, 255 out of the 617 *S.* Infantis isolates were analyzed by macrorestriction analysis after pulsed-field gel electrophoresis using the PulseNet CDC-protocol (Hunter *et al.* 2005).

Results and Discussion

The final typing scheme was established using 17 typing phages. Of the 617 *S.* Infantis strains analyzed, 605 could be typed with the established scheme, resulting in 61 different *S.* Infantis phage types (PT). The *S.* Infantis phage types PT 29 (30 %), PT 1 (21 %), PT 11 (7 %) and PT 9 (7 %), which are epidemiologically predominant, were found in humans and food as well as broilers.

197 strains isolated from food poisoning (40) and hospital outbreaks (11) were subtyped into 12 defined phage types (Figure 1). Remarkable was the emergence of S. Infantis as a nosocomial pathogen in several German hospitals. The most frequently observed clone in these outbreaks was PT 29/*Xba*I 27. This clone was repeatedly found in a hospital in Baden-Württemberg since 2002. In 2004 a huge outbreak with 188 cases in two clinics was investigated in Bavaria and traced back to bakery products. By phage typing and macrorestriction analysis the isolates from humans and food have been characterized to be identical (clone PT 53/*Xba*I 6). An outbreak with 80 cases in North Rhine-Westphalia in 2008 was caused by contaminated chicken kebab (clone PT 1/*Xba*I 34). A supra-

Figure 1: Distribution of *S.* Infantis phage types in Germany reported from humans (A) and broilers (B)



regional outbreak of *S.* Infantis in Thuringia, North Rhine-Westphalia and Lower Saxony was confirmed through clone PT 29/*Xba*I 27a which was found in isolates from humans and broilers. Additionally, some diffuse outbreaks could be detected by this complex typing system.

The EFSA studies have shown that the serovar *S.* Infantis is common in poultry. In this study broiler strains from Germany (n=143), Hungary (n=22), Australia (n=16), and Iceland (n=20) were subtyped using phage typing and macrorestriction analysis. A total of 24 phage types among these broiler strains were found.

In Germany clones PT 4/*Xba*I 4, PT 29/*Xba*I 5 and PT 29/*Xba*I 27 were frequently observed in isolates from broilers. The strains belonging to PT 29/*Xba*I 5 were associated with broilers imported from Hungary. This clone was found only in sporadic cases in Germany. Nogrady *et al.* (2007, 2008) reported recently that strains of PT 213 and PT 217 were most commonly found in Hungary, in humans as well as in broilers. The strains of PT 213 according to phage typing scheme of Laszlo correspond to PT 29 according to the phage typing scheme used at the NRC in Wernigerode. It is important to note that strains of PT 29/*Xba*I 27 from Germany and strains of PT 29/*Xba*I 5 from Hungary which are indistinguishable by phage typing differ in their macrorestriction patterns only in two bands of 70 kbp and 170 kbp, probably due to plasmids.

In contrast to the situation in Germany and Hungary, where clone PT 29 is epidemic among broilers, subtying of *S.* Infantis strains from broilers in Iceland showed a dominance of clone PT 61, which has not yet been observed in Germany. Pelkonen *et al.* (1994) were unable to confirm a relationship between isolates from humans and from poultry in Finland. *S.* Infantis repeatedly observed in cattle could explain epidemics in Finland during the 1970s (Lindqvist *et al.* 1999; Lindqvist & Pelkonen 2007). In the EFSA study it was also stated that in 2006 *S.* Infantis was the most frequent serovar found in beef (EFSA 2007c). By phage typing and macrorestriction analysis the spreading of specific *S.* Infantis clones in broiler flocks, the circulation of defined clones between countries, and the development of country-specific epidemiologic processes were detected.

In conclusion, the data presented in this study confirmed that *S.* Infantis strains are widespread in broiler flocks worldwide. In Hungary and Japan *S.* Infantis is the most frequent serovar in broilers (Nogrady *et al.* 2008; Ishihara *et al.* 2009; Noda *et al.* 2010). After successful vaccination against *S.* Enteritidis and *S.* Typhimurium in broiler flocks apparently other serovars may enter this ecological niche to persist whereas *S.* Infantis is a potential candidate. The phage typing scheme developed can be used for laboratory-based surveillance of *S.* Infantis.

Summary

Salmonella (*S.*) Infantis infections in humans transmitted by food are increasingly observed around the world. *S.* Infantis strains from several origins isolated between 2002 and 2009 were subtyped by phage typing and macrorestriction analysis (MRA). It was found that the 617 *S.* Infantis isolates investigated belonged to 47 defined phage-types and the 255 isolates characterized by MRA to 45 *Xba*I-types. The combination of these typing methods revealed a great diversity of clones among the *S.* Infantis isolates as well as occurrence of identical clones (PT 1/*Xba*I 34, PT 29/*Xba*I 27) in chicken meat and in humans in Germany over several years. Several hospital infections caused by these above-mentioned clones were also identified. Circulation of clone PT 29/*Xba*I 5 in broiler flocks between Hungary und Germany has been demonstrated by complex typing. The development of country-specific epidemiologic processes was also observed as PT 61 in Iceland. The change of predominant *Salmonella* serovars in the ecologic niche "broiler", vacated by vaccination against *S.* Typhimurium and *S .* Enteritidis, may lead to an epidemic increase of *S*. Infantis in broiler flocks. Routine application of the new phage typing scheme can be used to monitor the spread of *S.* Infantis.

Zusammenfassung:

Epidemiologische Zusammenhänge zwischen *Salmonella* Infantis-Isolaten von Mensch und Masthähnchen

Salmonella (S.) Infantis-Infektionen des Menschen, oft durch Lebensmittel übertragen, sind weltweit von wachsender Bedeutung. *S.* Infantis-Stämme verschiedener Herkunft, die von 2002-2009 isoliert wurden, sind durch die Lysotypie und die *Xba*I- Makrorestriktionsanalyse (MRA) subtypisiert worden. 617 der mit Lysotypie untersuchten *S.* Infantis-Isolate gehörten zu 47 definierten Lysotypen, und die 255 *S.* Infantis-Isolate, die mit der MRA charakterisiert wurden, zu 45 *Xba*I-Typen. Die Kombination (komplexe Typisierung) der beiden Methoden beweist die erhebliche klonale Diversität der *S.* Infantis-Isolate, zeigt aber auch das Vorkommen von bestimmten Klonen wie z. B. PT 1/*Xba*I 34 und PT 29/XbaI 27 sowohl bei Isolaten aus Masthähnchenfleisch als auch bei humanen Isolaten über Jahre hin in Deutschland. Es wurden auch mehrere Krankenhausinfektionen durch die benannten Klone in Deutschland erfasst. Die komplexe Typisierung wies weiterhin die Zirkulation des *S.* Infantil-Klons PT 29/*Xba*I 5 in Broiler-Beständen in Ungarn und Deutschland nach sowie die Existenz sog. länderspezifischer epidemiologischer Prozesse wie z. B. in Island durch den Klon PT 61.

Der offenbar durch die Vakzination gegen *S.* Typhimurium und *S.* Enteritidis begünstigte Erregerwechsel in der ökologischen Nische „Masthähnchen" könnte in der Zukunft dazu führen, dass *S.* Infantis in Masthähnchenbeständen häufiger zum Problemkeim wird. Deshalb kann der routinemäßige Einsatz des neuen Lysotypieschemas für *S.* Infantis dazu beitragen, die zeitliche und geografische Ausbreitung dieses Erregers zu überwachen.

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Patterns and dynamics of egg production in sub-regions of Europe

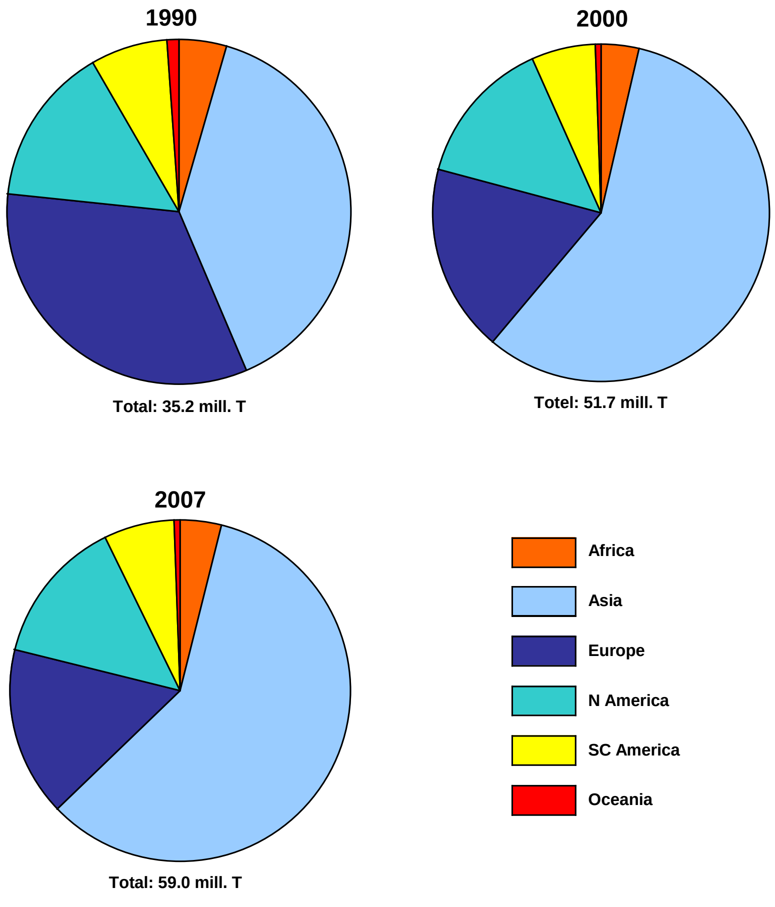
Hans-Wilhelm Windhorst

Introduction

ITo comply with EU regulations, less than 15 months are left until the January 2012 deadline, at which time all conventional cages must be replaced by enriched cages or non-cage systems. While egg producers in some countries are still hoping for an extension of the transition period, the changes during the past two decades documented in this study suggest that there will be winners and losers, but probably no shortage of supply.

World egg production increased from 35.2 million t in 1990 to almost 61 million t in 2008 or by 72.4 %. With a share of 58.8 % Asia dominated global production in 2008, whereas Europe lost almost half of its former contribution in the same time period (figure 1). The share of the EU member states fell from 17.8 % to 10.8 %. Nevertheless, European countries are in a leading position in global egg trade sharing almost two thirds of egg exports and of egg imports.

Figure 1: The changing contribution of the continents to global egg produduction in 1990, 2000 and 2007 (source: FAO database)



The dynamics in European egg production over the past two decades has been remarkable. The reason for the changes are on the one hand to be found in the political and socio-economic transformation processes in the former USSR and several Eastern European countries, not all of them were able to adapt to a market oriented economy within a short time, and on the other hand in the banning of conventional cages in the EU. Even though cages will be permitted until 2012, with the exception of Austria and Germany, the necessary transformation processes already begin to show impacts on egg production and trade.

The main goals of this paper are:

- to give an overview about the development of egg production in Europe between 1990 and 2008 on the basis of sub-regions,
- to identify countries with increasing, stagnating or decreasing egg production,
- to characterise the trade balance of the European sub-regions for shell eggs.

Development of egg production in the European sub-regions between 1990 and 2008

Between 1990 and 2008 European egg production decreased from 11.6 to less than 10 million t in 2008 (table 1). As can be seen from figure 2 the decrease was mainly a result of the new political and economic situation in Eastern Europe. The downward trend lasted until 1996, from then on most of these countries showed an increase in the production volume. In Western Europe, a decreasing egg production can be observed since 2001, a result of the development in France, Germany and the Netherlands. The steering factors behind this dynamics will be analysed in detail in a later chapter. Egg production in Northern and Southern Europe has been less fluctuating even though a decrease in the production volume can also be observed in some Southern European countries since 2004. This dynamics is also reflected in the contribution of the sub-regions to the overall egg production in Europe (figure 3).

Figure 2: Development of egg production in the sub-regions of Europe between 1990 and 2007 (source: FAO database)

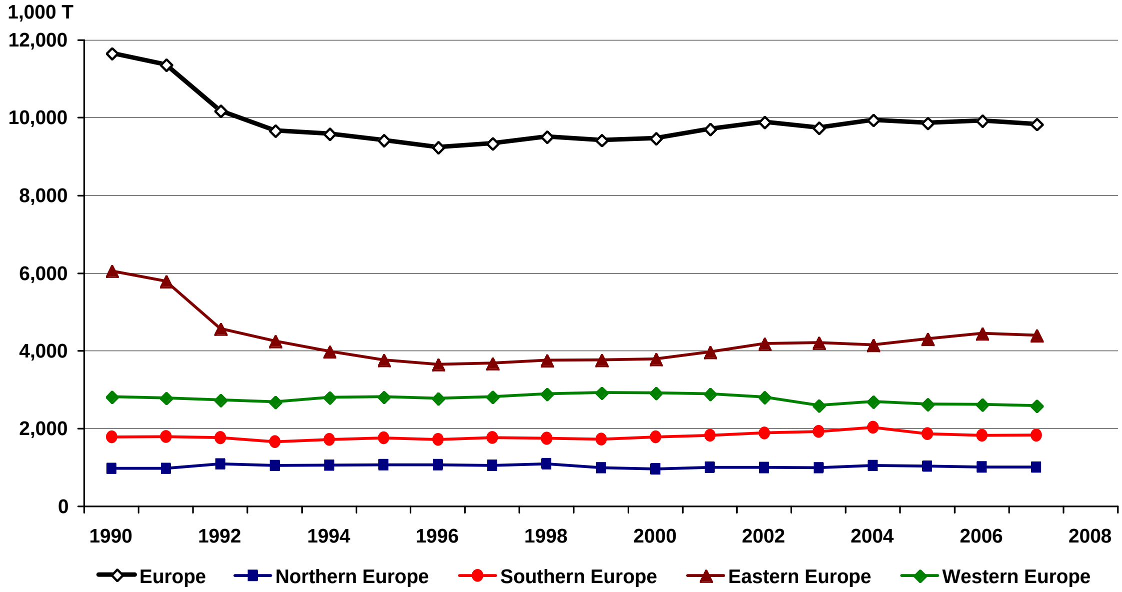
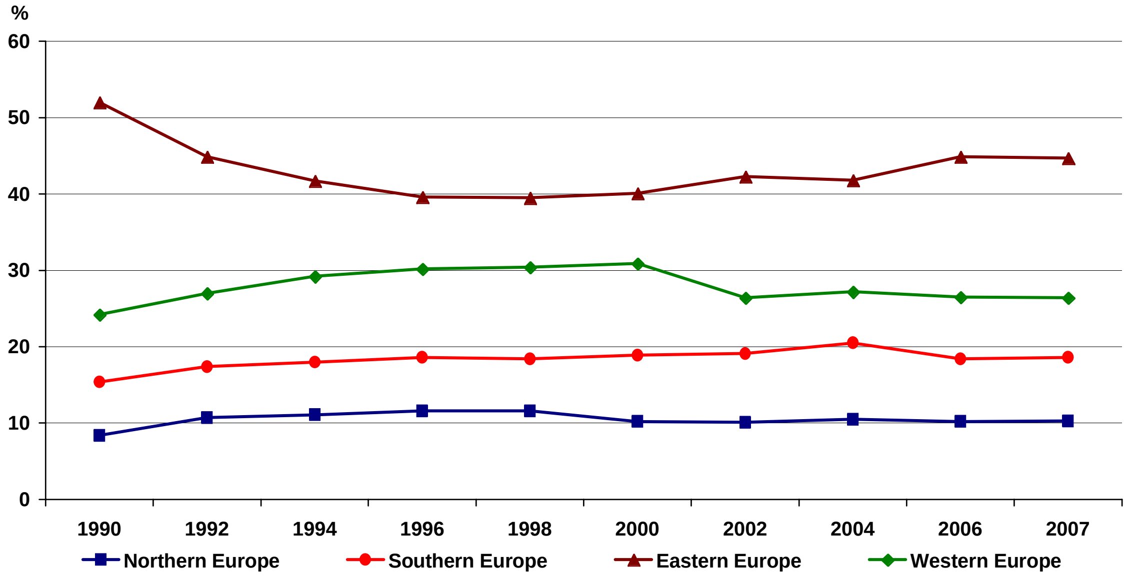


Table 1: The development of egg production in the European sub-regions between 1990 and 2008; data in 1,000 t (Source: FAO database)

Year	Northern Europe	Eastern Europe	Southern Europe	Western Europe	Europe
1990	981	6,067	1,790	2,821	11,659
2000	967	3,799	1,789	2,925	9,480
2008	1,027	4,526	1,837	2,605	9,995
Change (%)	+ 4.7	- 25.4	+ 2.6	- 7.7	- 14.3

Figure 3: The changing contribution of the sub-regions to Europaen egg produduction between 1990 and 2007 (source: FAO database)



Eastern Europe

Eastern European countries contributed 52.0 % to European egg production in 1990 (see figure 3). Because of the political and socio-economic transformation processes the production volume decreased rapidly in many countries in the subsequent years. As can be seen from figure 4, the adaption process to the new economic situation lasted several years and differed from country to country. In Poland, an upward trend can be observed as early as 1994, in Romania not before 2000. The egg industry in Hungary has not been able so far to stop the downward trend. A short period with an increasing production volume at the beginning of the decade was followed by another phase with decreasing production. In Bulgaria, the situation has been stabilising but the production volume is still lower than in 1990.

Figure 4: Development of egg production in Poland, Romania, Hungary and Bulgaria between 1990 and 2007 (Source: FAO database)

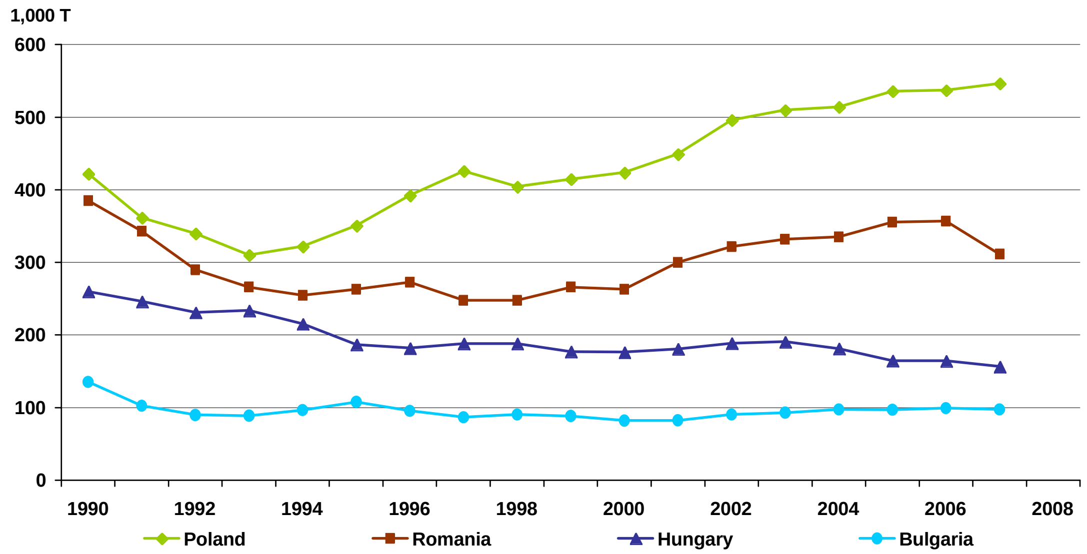


Table 2: The ranking of the Eastern European countries in egg production in 2008 (Source: FAO database)

Country	Production (1,000 t)	Share (%)
Russian Federation	2,119	46.8
Ukraine	855	18.9
Poland	582	12.9
Romania	334	7.4
Belarus	184	4.1
Hungary	159	3.5
Czech Republic	99	2.2
Bulgaria	94	2.1
Slovakia	71	1.6
Moldavia	30	0.7
Eastern Europe	4,526	100.0

The figures in table 2 show that the Russian Federation has a dominating position as egg producer in 2008 with a share of 46.8 %, followed by the Ukraine and Poland. Between 1993 and 2008, egg production in Poland increased by more than 270,000 t, in the Ukraine by almost 190,000 t and in Romania by 68,000 t. In contrast, the production volume in Russia was still 120,000 t lower than in 1993 and in Hungary 75,000 t. Obviously, the contrasting development had also an impact on European egg trade, for some countries have been able to become major egg exporting countries, for example Poland. The regional concentration in Eastern Europe is very high, a result of the dominating position of the Russian Federation. The three leading countries contributed 78.6 % to the overall egg production of this sub-region.

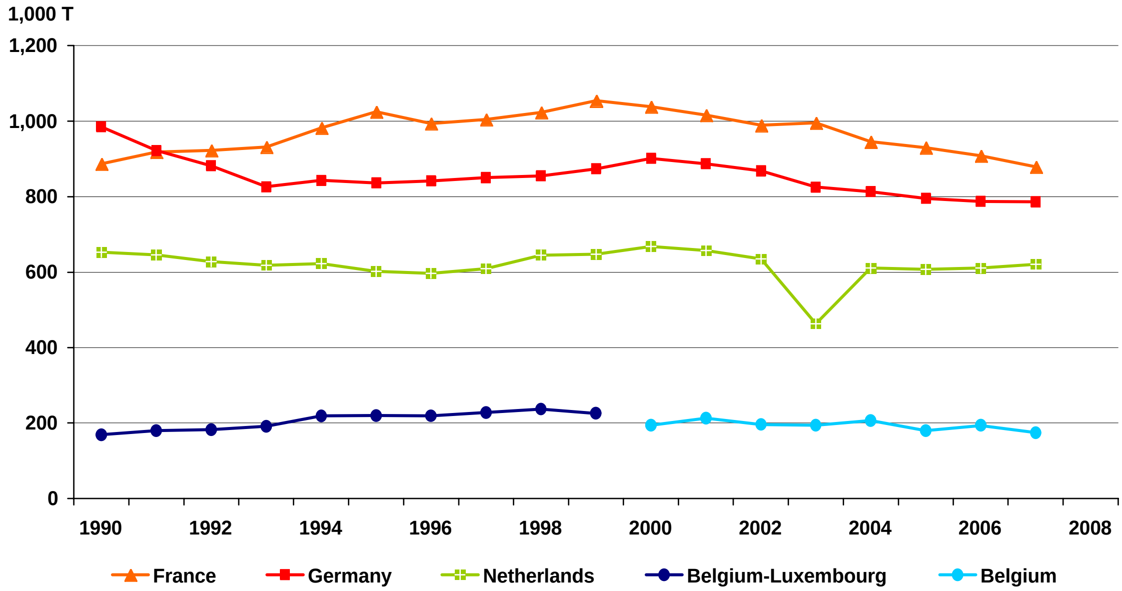
Western Europe

In 1990, Western European countries shared 24.2 % of the European egg production (figure 3). Because of the decrease of the production volume in Eastern Europe in the early 1990s, Western European countries could expand their contribution to 30.9 % in 2000. From then on a downward trend can be observed, on the one hand a result of the decreasing production volume in several countries and on the other of the recovery of the egg industry in a number of Eastern European countries. Egg production in 2008 was 216,000 t lower than in 1990 (table 1).

A closer look at the development in selected countries shows the remarkable dynamics (figure 5). In France, egg production increased considerably between 1990 and 1999 before it started to decrease continuously. This reflects the general crisis of the French poultry industry for a similar dynamics can be observed in the poultry meat sector (Herczeg 2010). The low competitiveness of the French poultry farmers, which becomes obvious in decreasing exports and increasing imports, seems to be the main steering factor. Because of the high labour costs and very often only small flock sizes, the production costs are considerably higher than in the countries with which they have to compete.

A significant decrease of egg production occurred in Germany in the early 1990s, a result of the collapse of many large state farms in the former German Democratic Republic. The situation stabilised between 1993 and 2000, from then on, however, a continuous shrinking of the production volume can be observed. The latter is mainly due to the banning of conventional cages three years earlier than in most of the other EU member countries. A second decrease happened in 2009 when all conventional cages had to be abandoned. The self sufficiency rate fell to 55.8 % and the import volume of shell eggs for consumption was as high as 7 billion eggs (Windhorst 2009). Between 1990 and 2002 Dutch egg production hovered around 600,000 t. The Avian Influenza outbreak in 2003 led to a sharp decrease. Even though the egg industry has been recovering from this blow, the production volume is still lower than in 2000 (Windhorst 2010a). Egg production in Belgium has been fairly stable over the whole time period.

Figure 5: Development of egg production in France, Germany, the Netherlands, Belgium-Luxembourg and Belgium between 1990 and 2007 (source: FAO database)



A closer look at the contribution of the Western European countries to the egg production volume of this sub-region and their ranking (table 3) reveals that in spite of a decreasing production France, Germany and the Netherlands dominated egg production. In 2008, they shared 88 % of the production volume of this sub-region. All other countries were of minor importance. This is in particular true for Luxembourg, Austria and Switzerland. The two latter have become major egg importing countries over the past years.

Table 3: The ranking of the Western European countries in egg production in 2008 (Source: FAO database)

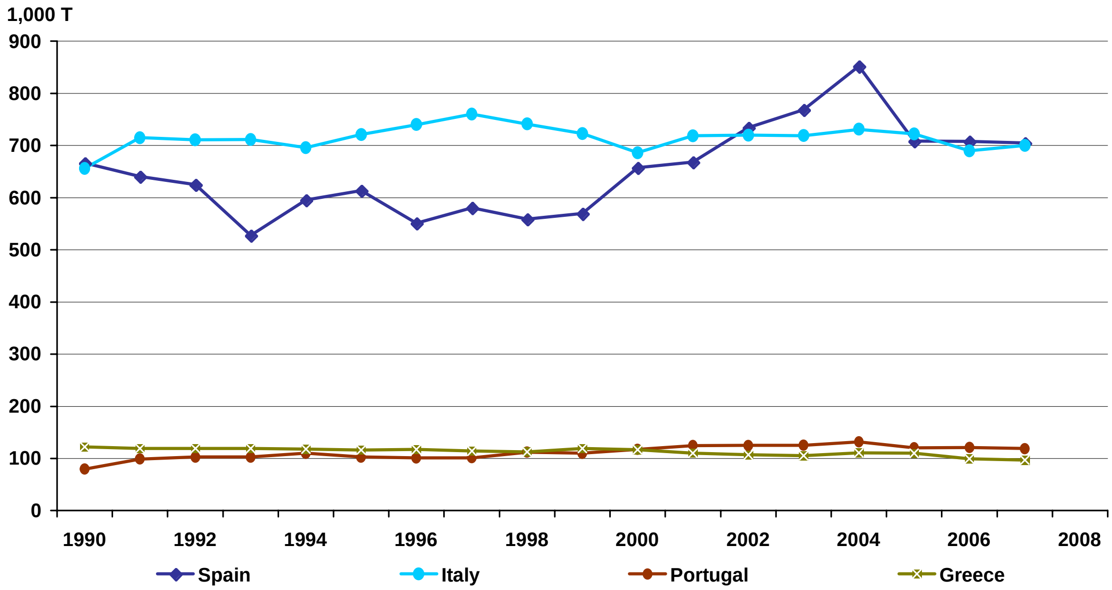
Country	Production (1,000 t)	Share (%)
France	879	33.7
Germany	787	30.2
Netherlands	627	24.1
Belgium	175	6.7
Austria	96	3.7
Switzerland	39	1.5
Luxembourg	1	0.0
Western Europe	2,605	100.0

Southern Europe

Southern European countries shared 18.4 % of the European egg production in 2008, 3 % more than in 1990 but 2.3 % less than in 2004. The downward trend is mainly a result of the dynamics in Spain and Italy.

Italian egg production reached a peak in 1997 (figure 6). In the following years the production volume differed considerably from one year to the other, resulting from various Avian Influenza outbreaks in northern Italy. Since 2006 the production volume has been hovering around 700,000 t. The Spanish egg industry has shown a remarkable dynamics over the past ten years (Windhorst 2010b). Between 1999 and 2004, egg production increased by almost 200,000 t. The main steering factors behind this dynamics were a fast growing per capita consumption and growing exports. When The Netherlands had to reduce their exports because of the Avian Influenza outbreak, new markets for Spanish egg producers opened in Germany, France and the United Kingdom. With the recovery of the Dutch egg industry and the new role of Poland as a major egg exporting country, the Spanish egg industry lost important markets. Rising production costs because of higher feed costs, the devaluation of the English pound, high investment costs to control Salmonella infections in layer flocks as well as a reduction of per capita consumption because of high egg prices were the main steering factors behind the reduction of egg production and shell egg exports. In 2009 a considerable number of hen houses were left empty. Since 2005 egg production has been fairly stable at about 700,000 t, for 2009 a further decrease has been projected, however. Egg production in Portugal and Greece is considerably lower than in Spain and Italy; in Portugal a slight increase of the production volume can be observed.

Figure 6: Development of egg production in Spain, Italy, Portugal and Greece between 1990 and 2007 (source: FAO database)



As can be seen from the data in table 4, Spain and Italy shared 76.5 % of the production volume of this sub-region. Egg production in all other countries was much lower. It is worth noting that Albania more than doubled its production since 1990.

Table 4: The ranking of the Southern European countries in egg production in 2008 (Source: FAO database)

Country	Production (1,000 t)	Share (%)
Spain	705	38.4
Italy	700	38.1
Portugal	124	6.8
Greece	97	5.3
Serbia	60	3.3
Croatia	47	2.6
Albania	27	1.5
Bosnia a. Herzegovina	26	1.4
Slovenia	22	1.2
Macedonia	18	1.0
Malta	7	0.4
Montenegro	4	0.2
Southern Europe	1,837	100.0

Northern Europe

With a production volume of slightly over 1 million t the Northern European countries contributed 10.3 % to European egg production in 2008. From figure 7 one can see that egg production has not changed very much in the analysed time period in Denmark, Finland and Norway. In contrast, the production volume of the United Kingdom has been fluctuating considerably after 1998 when a peak was reached. This dynamics is closely related to the decision of several food retailers to no longer list eggs from cage production. Farmers who were not willing to invest in alternative forms of keeping laying hens quit production. On the other hand, several new free range farms, some of them with remarkable size, and farms with so called colony nests (a form of enriched cage) were built. Even though free range eggs are preferred by British consumers, eggs from colony nests gained market shares over the past years.

Figure 7: Development of egg production in the United Kingdom, Denmark, Finland and Norway between 1990 and 2007 (source: FAO database)

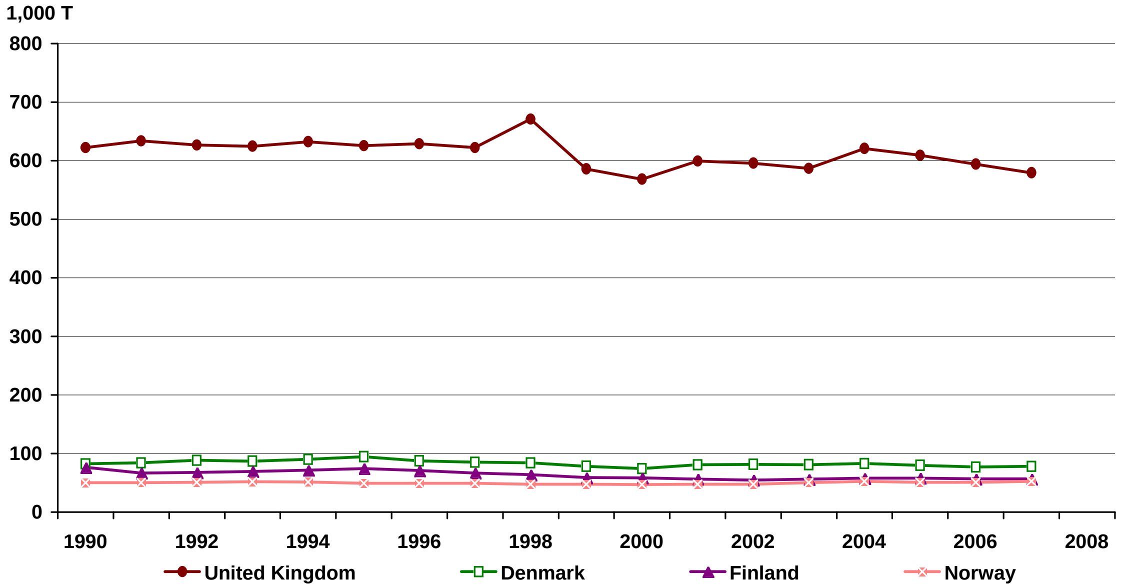


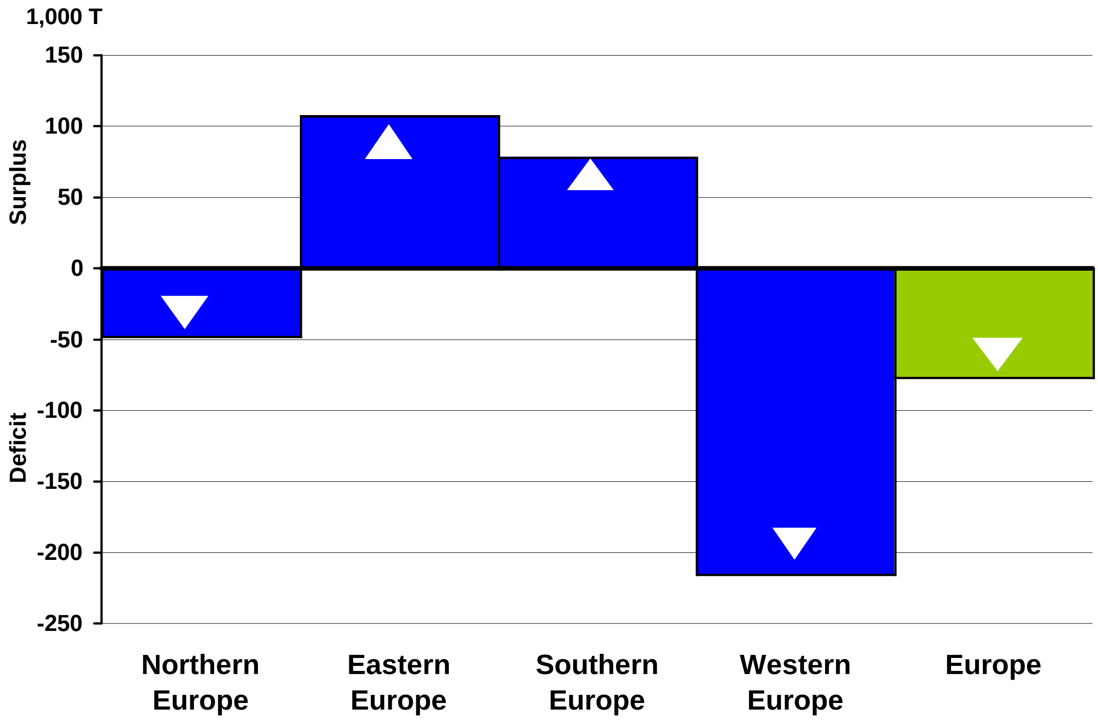
Table 5: The ranking of the Northern European countries in egg production in 2008 (Source: FAO database)

Country	Production (1,000 t)	Share (%)
United Kingdom	600	58.4
Sweden	95	9.3
Denmark	81	7.9
Finland	58	5.6
Lithuania	55	5.4
Norway	53	5.2
Latvia	40	3.9
Ireland	33	3.2
Estonia	9	0.9
Iceland	3	0.3
Northern Europe	1,027	100.0

Table 6: The top ten countries in European egg production in 2008 (Source: FAO database)

Country	Sub-region	Production (1,000 t)	Share (%)
Russian Federation	Eastern Europe	2,118.5	21.2
France	Western Europe	879.0	8.8
Ukraine	Eastern Europe	855.2	8.6
Germany	Western Europe	786.7	7.9
Spain	Southern Europe	705.0	7.1
Italy	Southern Europe	700.0	7.0
Netherlands	Western Europe	627.0	6.3
United Kingdom	Northern Europe	600.1	6.0
Poland	Eastern Europe	581.7	5.8
Romania	Eastern Europe	333.6	3.3
10 countries	-	8,186.8	82.0
Europe	-	9,995.0	100.0

Figure 8: Trade balance for shell eggs in the sub-regions of Europe in 2007
(Source: Own calculations)



With a share of 58.4 %, the United Kingdom was the dominating egg producing country in this sub-region. It was followed by Sweden, Denmark and Finland. Together they contributed 22.8 % to the overall production volume of this sub-region. While Latvia and Lithuania could expand their egg production since 1990, it is still decreasing in Estonia.

High regional concentration and negative trade balance

In 2008, the top 10 countries accounted for 82 % of the egg production in Europe (table 6). With a share of 21.2 % Russia was in a leading position. Four of the top ranked countries were located in Eastern Europe, three in Western Europe, two in Southern Europe and only one in Northern Europe.

In 2007, the European trade balance with shell eggs for consumption was negative (figure 8). About 76,000 t of eggs had to be imported to meet the demand. The highest negative balance showed Western Europe with 215,000 t, the highest positive balance Eastern Europe with 108,000 t. It can be expected that the negative balance will increase over the next years because of the banning of cages in the EU from 2012 on and the necessary transformation process to alternative forms of keeping laying hens.

Main results

The main results of the analysis can be summarised as follows:

- The dynamics of egg production in the four European sub-regions differed considerably between 1990 and 2008.
- In Eastern Europe, the production volume decreased in Russia, Hungary and the Czech Republic whereas it increased in Poland.
- In Western Europe, production decreased in France, Germany and The Netherlands. In all other countries the production volume did not change very much.
- In Southern Europe, egg production increased in Spain (until 2004), Portugal and Albania whereas Greece and Italy had to face a downward trend.
- In Northern Europe, only the United Kingdom showed a considerable dynamics, mainly a result of the decision of food retailers to no longer list cage eggs.
- The regional concentration in European egg production is quite high. In 2008, 82 % of the overall production was concentrated in the ten leading countries, 30 % in the top two ranked countries.
- In 2007, the European trade balance with shell eggs for consumption was negative by 76,000 t.

Zusammenfassung

Muster und Dynamik regionaler Verschiebungen der Eierproduktion in Teilregionen Europas

Die europäischen Teilregionen wiesen im Zeitraum von 1990 bis 2008 bezüglich der Entwicklung der Eierproduktion eine sehr unterschiedliche Dynamik auf. In Osteuropa nahm die Erzeugung in Russland, Ungarn und der Tschechischen Republik deutlich ab, während es in Polen zu einem schnellen Anstieg kam.

In Westeuropa verringerte sich das Produktionsvolumen in Deutschland, Frankreich und den Niederlanden. In den übrigen Ländern erfolgten keine stärkeren Veränderungen. In Südeuropa kam es ähnlich wie in Osteuropa zu gegenläufigen Entwicklungen. Während in Spanien (bis 2004), Portugal und Albanien die Eiererzeugung ausgeweitet wurde, ging sie in Italien und Griechenland zurück. Die Ursachen sind zum einen im Ausbruch der Aviären Influenza zum anderen in anhaltenden ökonomischen Problemen zu sehen. In Nordeuropa traten insgesamt nur geringe Veränderungen auf, nur im Vereinigten Königreich kam es ab 1998 zu einer stärkeren Dynamik, die ausgelöst wurde durch eine Umstellung auf Boden- und Freilandhaltung im Gefolge der Entscheidung des Lebensmitteleinzelhandels, keine Eier aus Käfighaltungen mehr zu listen. Die regionale Konzentration in der europäischen Eierproduktion ist sehr hoch. Auf die zehn führenden Staaten entfielen 2008 82,0 % der Gesamterzeugung, auf die beiden führenden Staaten Russland und Frankreich allein 30 %. Europa wies 2007 ein Defizit im Handel mit Schaleneiern zum Verzehr von 76.000 t auf. Mittelfristig ist mit einem deutlichen Anstieg der negativen Handelsbilanz zu rechnen, weil das Verbot der Käfighaltung ab 2012 in allen Mitgliedsländern der EU zumindest für einige Jahre zu einer deutlichen Verringerung des Produktionsvolumens führen wird.

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Present status of the world goat populations and their productivity

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Introduction

Goats were among the first farm animals to be domesticated. As indicated by the archaeological evidence, they have been associated with man in a symbiotic relationship for up to 10,000 years (Ensminger and Parker, 1986). Goats disseminated all over the world because their great adaptability to varying environmental conditions and the different nutritional regimes under which they were evolved and subsequently maintained. They proved useful to man throughout the ages due to their productivity, small size, and non-competiveness with him for food.

In the developing countries, goats make a very valuable contribution, especially to the poor in the rural areas. The importance of this valuable genetic resource is underestimated and its extent of contribution to the livelihood of the poor is inadequately understood. They are often neglected in comparison with cattle and sheep. Part of this attitude towards them can probably be due to a recognition of their capability, rather any prejudice against them, as it is believed that goats are intelligent, independent, agile, tolerant to many diseases and parasites and can look after themselves much better than other livestock species.

Research and development investments to improve the relatively low level of goat's productivity do not match their potential importance, resulting in many goat breeds that are not genetically explored, especially in the developing countries. Nevertheless, goats are going to be more important source of livelihood for many more people in coming years and, thus, they deserve greater attention at both the micro and macro levels. Now, it is the time to consider and pay attention to the value and capacity of goats for producing food. This article discusses and reviews the present status of the world goat populations and their productivity.

Number of goats in the world:

Accurate statistics are required to determine the future outlook of the goat populations and their productivity. They are also needed before any improvement policies can be planned on a realistic basis and implemented with confidence. Table 1 presents numbers of goat and sheep populations in different parts of the world, along with the ratios of goat to sheep and their percentages out of the total number of goats and sheep in the world (FAOSTAT, 2008).

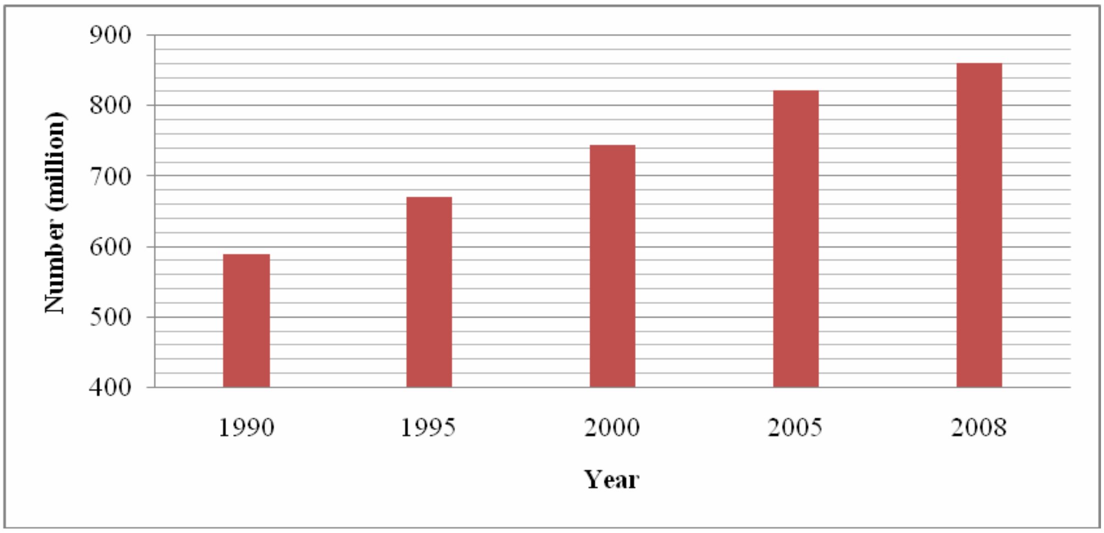
Table 1: Numbers of goats and sheep in different parts of the world, ratio of goat to sheep per each and their percentages out of the world total number (FAOSTAT, 2008)

Continent	Number (million)		Ratio		Percentage of world total (%)	
	Goats	Sheep	Goats	Sheep	Goats	Sheep
Asia	514.4	452.3	1	0.9	59.7	42.0
Africa	291.1	287.6	1	1.0	33.8	26.7
Northern America	3.0	6.9	1	2.3	0.4	0.6
Central America	9.0	8.1	1	0.9	1.0	0.8
Caribbean	3.9	3.1	1	0.8	0.5	0.3
South America	21.4	73.1	1	3.4	2.5	6.8
Europe	18.0	133.9	1	7.4	2.1	12.4
Oceania	0.9	113.1	1	119.2	0.1	10.5
World	861.9	1078.2	1	1.25		

The world total numbers of goats and sheep were 861.9 and 1078.2 million, respectively, i.e. there is about one goat to approximately 1.25 sheep in the world (FAOSTAT, 2008). There are tremendous variations among the different parts of the world regarding the number of goats, its ratio to sheep and their percentages. The largest number of goats is observed in Asia, followed by Africa, representing about 59.7% and 33.8%, summing up to 93.5% out of the total number of the world, respectively. The lowest number of goats is found in Oceania, accounting for 0.1% out of the world total number. The ratio of goat to sheep ranged between one goat to 0.8 sheep in the Caribbean to one goat to 119.2 sheep in Oceania. The ratios of goat to sheep in Africa, Central America and Asia are approximately equal, indicating the considerable importance of goat populations in these parts of the world, especially to the poor and landless peasants.

The total number of goats in the world increased by 146% of the total number (590.1 million) encountered in 1990. Number of goats in the world has been increasing since 1990 by about 1% to 4% each year (Figure 1). During the same period, cattle number increased by 5%, while that of sheep decreased by 10%, reflecting the emergence of goats as a major livestock species.

Figure 1: Number of goats in the world during the period from 1990 to 2008 (FAOSTAT, 2008)



The total numbers of goats in the top ten countries are presented in Table 2. The ten countries have approximately 65.7% of the world total number. Seven countries of this list are in Asia, and the rest is in Africa. The largest number of goats in the world is in China, followed by India, Pakistan and Bangladesh, all of them are in Asia. Number of goats in these four countries constitutes about 45% of the world total. Great variation in terms of the ratio of goat to sheep exists among them, ranging between 1 goat to 0.02 sheep in Bangladesh to 1 goat to 2.13 sheep in Iran.

Goat Production:

Goats are mainly kept: to produce milk, meat or fiber (Mohair and Cashmere). This article focuses on meat and milk production, as there is little information on fiber production.

Milk

Dairy goat is considered the cow of the poor. The goat eats little, occupies a small area and produces enough milk for the average unitary family, whereas maintaining a cow at home cannot be afforded by the homeowner, hence, the growing popularity of goat as the poor person's cow. Dairy goats produce about 15.2 million metric tons (MT) of milk, accounting for about 2% of the world total amount of milk produced by livestock species (FAOSTAT, 2008). The developing countries produce approximately 83% of the total amount. In Europe, goat breeding is strongly oriented towards milk production, with

Table 2: Numbers of goats in the top ten countries, the ratio of goats to sheep and their percentages from the total number in the world (FAOSTAT, 2008)

Continent	Number (million)		Ratio		Percentage of world total (%)	
	Goats	Sheep	Goats	Sheep	Goats	Sheep
China	149.4	136.4	1	0.91	17.3	12.7
India	125.7	65.0	1	0.51	14.6	6.0
Pakistan	56.7	27.1	1	0.48	6.6	2.5
Bangladesh	56.4	1.6	1	0.02	6.5	0.2
Nigeria	53.8	33.9	1	0.63	6.2	3.1
Sudan	43.1	51.1	1	1.19	5.0	4.7
Iran	25.3	53.8	1	2.13	2.9	5.0
Ethiopia	21.8	25.0	1	1.15	2.5	2.3
Mongolia	20.0	18.4	1	0.92	2.3	1.7
Indonesia	15.8	8.4	1	0.53	1.8	0.8
World	861.9	1078.2	1	1.25		

only 3% of the world goat population producing about 15% of the world's goat milk, which is mostly used for cheese production (Lejaouen and Toussaint, 1993). Table 3 shows the amount of goat milk produced by the top ten countries in the world, along with the total number of dairy does and the average of milk produced per doe (FAOSTAT, 2008).

Table 3: The amount of goat milk produced in the top ten countries, number of dairy goats and the average amount of milk produced by a dairy doe

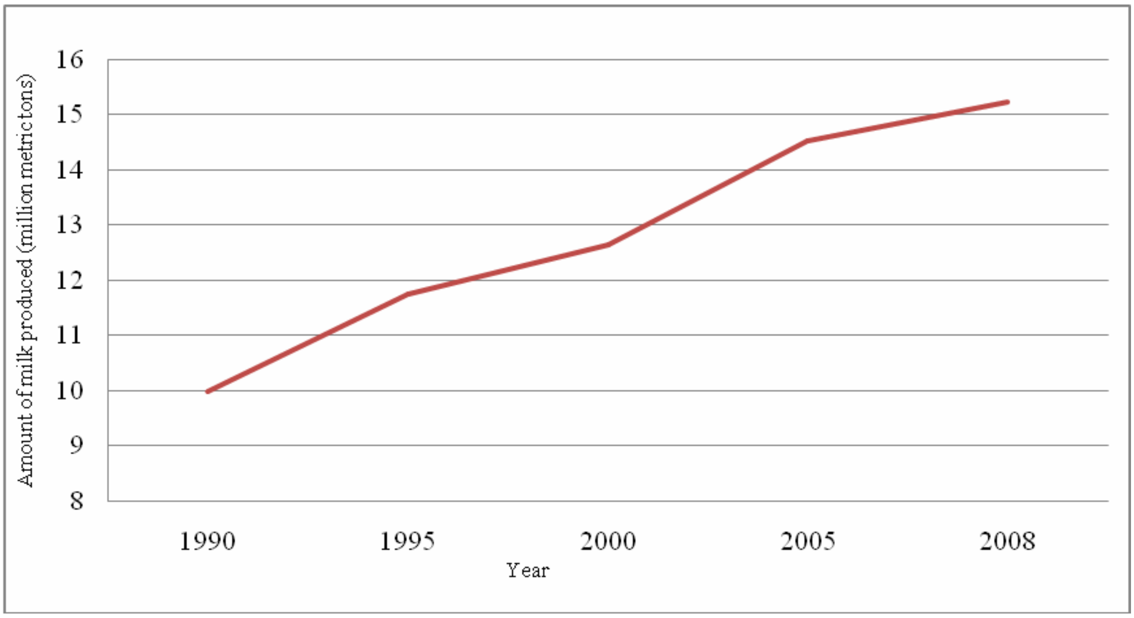
Country	Goat Milk production (million MT)	Number of dairy goats (million)	Milk produced per dairy doe (kg)
India	4.0	30.2	132.5
Bangladesh	2.2	27.1	80.0
Sudan	1.5	N.A.	-
Pakistan	0.7	4.9	141.9
Spain	0.6	1.4	422.3
France	0.6	0.8	703.8
Greece	0.5	4.1	123.9
Iran	0.4	13.7	29.9
Somalia	0.4	6.6	59.7
China	0.3	1.4	194.8

The largest amount of goat milk is produced in India, followed by Bangladesh and Sudan. There are three European countries in the list producing a considerable amount of goat milk: Spain, France and Greece. These three countries produce similar amounts of goat milk. In France, interest in dairy goats has led to the establishment of organized programs for selection, processing and commercialization of goat milk, which is produced mainly from Saanen and Alpine breeds. France leads the list in terms of the annual milk production per dairy doe, while Iran reports the lowest milk production per dairy doe. China has the largest total number of goats in the world, but they are mainly kept for meat production. Milk production per dairy doe ranks third, behind France and Spain. China officially reports 1.4 million dairy goats producing 0.3 million MT of milk (FAOSTAT, 2008). According to Luo (2009), China had about 5.8 million dairy goats in 2008. Both sources of statistics on goats may be questioned because they are not based on actual censuses, and the number of dairy goats is even more difficult to count due to the lack of breed definition.

Since 1990, interest in dairy goats has been steadily increasing, as manifested by the increase in milk production from about 10 million MT in 1990 to about 15.2 million MT in 2008 (Figure 2). The dairy goat industry has great potential for further growth. It has grown partly because of a trend towards self sufficiency by rural people, especially in developing countries, where goat milk can help to improve the nutrition of millions of people. In developing countries, much of the milk produced by goats is for family consumption, but goat milk can also be further processed into a variety of marketable products.

Marketing of goat milk and its products is still in its infancy. So far, there have been no marketing efforts attempted on a broad scale. As reported by Dubeuf and Boyazoĝlu (2009) and Luo (2009), less than 5% of the total milk produced by goats is marketed.

Figure 2: Total amount of goat milk produced during the period from 1990 to 2008 (FAOSTAT, 2008)



There are many challenges facing the dairy goat industry, including collecting complete and reliable data on all aspects of production through developing nationwide strategies, identifying superior and proven bucks that accelerate the genetic improvement in the commercial herds and solving the seasonality problem to ensure consistent flow of goat milk. Seasonal breeding and the resulting annual fluctuations in goat milk supply have made development of new markets difficult and have dampened the importance of milk yield as a breeding goal (Haenlein, 1984). The development of a professional marketing system is part of the challenge to benefit from the fact that many people consuming dairy products prefer products from goats.

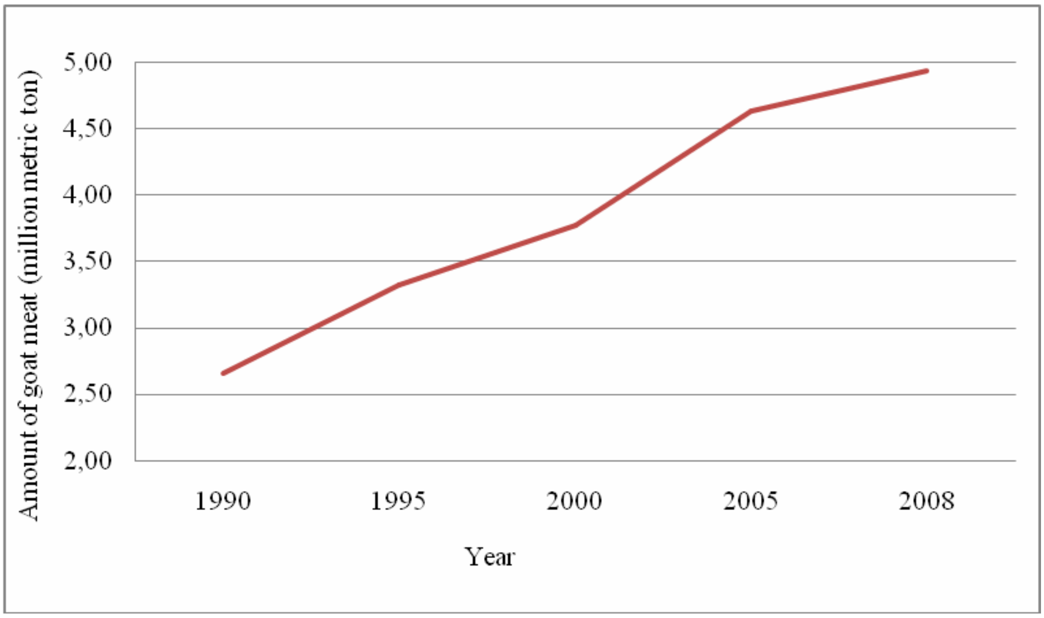
Meat Production

Goat meat is widely consumed in the developing countries. According to FAOSTAT (2008), total meat inventory is about 280 million MT. Goat meat represents only 2% of this total. The total amount of goat meat produced in 2008 was 4.9 million MT. The developing countries produced approximately 97% of this amount, reflecting the great importance of goat meat to feed millions of people in these countries. The top ten countries producing goat meat are presented in Table 4. China leads the world in producing goat meat, accounting for 38% of the world total goat meat produced. The top ten countries producing goat meat are all from Asia and Africa, indicating the importance of goat meat to the people living in these areas. Goat meat production has been increasing from 2.65 million MT in 1990 to 4.93 million MT in 2008 (Figure 3). The major part of this amount is not traded as other major meats. It is usually produced and consumed locally among the poor in the developing countries. A profitable goat meat business can be ensured by proper knowledge of goat husbandry, budgeting and marketing techniques. There are several challenges associated with increasing meat production including consumer education, producer education, lack of slaughter and processing plants and lack of organized breeding programs and markets and marketing channels.

Table 4: The amount of goat meat produced in the top ten countries, number of animals slaughtered and the average amount of meat produced per animal

Country	Total meat (million MT)	Number of animals slaughtered (million)	Average meat produced per animal (kg)
China	1.8	133.3	13.7
India	0.5	47.8	10.0
Nigeria	0.3	21.3	12.7
Pakistan	0.3	15.4	17.0
Bangladesh	0.2	30.0	7.0
Sudan	0.2	14.5	13.0
Iran	0.1	7.6	14.0
Indonesia	0.1	6.6	10.0
Ethiopia	0.1	7.6	8.5
Niger	0.1	4.4	12.0

Figure 3: Increasing world total goat meat production since 1990



The potential of goats for sustainable supply of milk and meat for human consumption is unquestioned, and their contribution to improved nutrition of rural people is likely to increase. At the same time, goat cheese consumption is likely to increase also in developed countries. This is attributed to the image of goat cheese being a product of natural farm conditions compared with milk and milk products from high yielding dairy cattle in large industrial farms. Regarding goat meat, rising living standards in some parts of the world and the migration of people preferring goat meat to the developed countries, have increased the demand for goat meat in these areas (Alandia Robles *et al.* 2006). Government programs to support goat farming should focus on research and education in the areas of breed improvement, farm management, control of infectious diseases, milk collection, processing and marketing.

Breeding goals and genetic improvement:

A global overlook of the goat industry indicates that few well organized selection programs have been developed, although goats have the biggest increase in number among the livestock species during the last 20 years (Dubeuf and Boyazoĝlu, 2009). Increased numbers do not necessarily indicate a positive development of productivity, but simply reflect the fact that many people in rural areas of the developing countries try to survive by keeping small animals such as goats. Selection programs have been established mainly in developed countries, while most goats in developing countries are randomly bred and mainly used to satisfy the immediate needs of the families. A few breeding programs had been established in developing countries, but most of them failed. Most of these projects have focused on goat improvement rather than on educating the people who kept the animals. A limited number of selected and well characterized breeds for producing milk, meat or fiber has been developed, while the majority is not genetically exploited as a result of the lack of selection schemes and breeding organizations (Gall, 1996). In addition, the production systems are mostly extensive, which make record keeping very difficult, resulting in underutilization and inadequate exploitation of many potentially valuable breeds. The research and breeding work has been carried out mainly by research organizations, with little participation of the farmers. Several crossbreeding programs have also been established in different countries to obtain suitable and improved genotypes. In Turkey, for example, the Saanen breed was crossed to the Turkish breed “Kili” and the resulting cross became the most popular improved dairy goat (Yener, 1989).

Most organizations engaged in the genetic improvement of goats are located in developed countries and dedicated to milk production. France leads in the development of successful breeding plans for dairy goat production. Two breeds, the French Alpine and the Saanen, predominate. Breeding values are estimated for milk, total protein, total fat, percent protein and percent fat, and then combined into an index called ICC (Index Combine Caprine). This index does not include the amount of milk produced. Recently, typing the animal weighted towards the shape and attachment of the udder and the placement of teats has been introduced using a type score. The Spanish selection program for improving goat milk production and its constituents has started in 1993 for some local breeds as Murcrana Granadina, Malagueňa and Majorera. The program was based on milk yield as a selection criterion and now changed to protein yield and content (Analla *et al.* 1995). In the USA, genetic evaluation of dairy goats started in 1983 for bucks and in 1984 for does of Alpine, Experimental, La Manchas, Anglu Nubian, Saanen and Toggenberg breeds and their crosses (Wiggans and Hubbard, 2001). Genetic evaluation is performed for milk, fat and protein yield and some type traits, and combined into an index as a sire evaluation program (Wierschem and Dickinson, 1989). A test day model is used for breeding value estimation and genetic improvement of yield traits for dairy goats (Sullivan and Wiggans, 2000). In Italy, selection programs are limited to research centers and universities. In South Africa, the Boer goat is selected for meat production. The systematic application of selection schemes has started in China mainly for the Boer goat (Dubeuf and Boyazoĝlu, 2009).

Clear and correct identification of the breeding objectives is the core of any breeding program to be established (Groen, 2000). Progress towards the proposed breeding goals cannot be achieved without accurate evaluation of the genetic merit of each individual animal. The breeding objectives for any genetic improvement of goat productivity are focusing mainly on meat, milk or fiber, while at the same time maintaining high levels of adaptation to the local environmental conditions and the availability of feed resources. Greater rates of genetic improvement are most likely with improving the economies of goat productivity. Such rates cannot be accelerated unless the number of progeny per buck is large. This is achieved by using artificial insemination coupled with short generation interval. Theoretically, there is no limit to the number of selection criteria that may be included in a selection index defining the overall breeding goal, but from a practical point of view it is better to keep the program simple. The breeding program should also be flexible and allow the incorporation of new selection criteria. The following points should be remembered:

- The more criteria that are considered for selection, the slower the rate of progress per trait.
- Each additional trait included in the index should contribute to more accurate breeding value estimation and higher rate of progress in overall merit.
- Including additional traits must be cost-effective.
- In a national program, the participants should not be obliged to select on exactly the same criteria, but major criteria should be commonly considered.

For breeding programs concentrating on milk, the objective should be "Enhancement of the quality and quantity of milk produced from healthy animals that are easy to milk in order to achieve high profitability". The following main criteria can be considered:

Volume of milk: It is the most obvious characteristic for any dairy animal. It is usually included as a criterion in any breeding program. However, it may not be incorporated in a selection index, as milk volume is made up of solids, mainly fat, protein and sugar, in addition to water. In any case, milk volume must be measured.

Fat: The fat content is important for the quality of processed products. However, continued selection for increased fat content of the milk is not desirable. Thus, it is preferred to increase the total fat produced per due, while keeping the same level of concentration. In France, both criteria are included in a selection index.

Protein: Good cheese making depends on the concentration of protein in the milk. So, protein is a major component in any selection scheme for dairy animals.

Total solids: This trait can be used as composite selection criterion for fat and protein.

Cell count: This trait is an indicator for the bacteriological status of the milk and it seems to be a tool for management rather than breeding. However, recent research has shown that this trait is also moderately heritable (Rupp *et al.* 2004) and can thus be improved by breeding.

Management criteria: These criteria have great impact on the profitability of the dairy goat herds. Ease of milking and udder shape compatible with rapid machine milking are criteria which need to be improved. Udder shape is moderately heritable (Luo *et al.*, 1997) and can be improved by genetic selection. Another trait of interest is faecal egg count used as indicator for disease resistance (Woolaston and Baker, 1996).

Other criteria: Recent advances in molecular genetics techniques increased our understanding of animal's genome and the identification of genes associated with functional activities. For example, French researchers identified a major gene for alpha s1 casein that has an effect on protein production (Grosclaude, 1987). This allele is particularly useful for manufacturing cheese. As this gene and others yet to be discovered are simply inherited, they can be incorporated in selection programs.

In a breeding program focusing on improving meat production, the key traits to be considered are adaptability, reproduction, growth rate and carcass characteristics.

Adaptability: This trait is the most important of all the production traits. Although the goat has proven to be the most adaptable of all domesticated livestock and survives in a wide range of environments worldwide, it does not always realize its production potential when taken out of one environment and placed in another. Adaptability is a trait with low heritability and therefore difficult to improve by selection. It includes a range of adaptive traits which enable goats to survive and be productive, including disease resistance, heat resistance, water tolerance, ability to cope with poor feed quality (Baker and Gray, 2004).

Reproduction: For animals kept primarily for meat production, reproductive rate is the most important factor contributing to the efficiency of production (Shelton and Willingham, 1992). Reproductive traits of interest in a meat goat enterprise would be conception rate, kidding rate and the ability to breed out of season. Prolificacy is also an important reproductive criterion. It should be noted that goats of the temperate zones tend to be seasonal breeders, while those from the tropics are non-seasonal breeders and kid year-round. This desirable trait of non-seasonality should be incorporated in a meat goat enterprise. Multiple births should be given high priority in the breeding programs, if the income is derived primarily from selling the kids.

Growth Rate: Growth can be effectively divided into two periods: pre-weaning average daily gain (ADG) and post-weaning ADG. Pre-weaning ADG reflects the genetic potential of the kid and the mothering ability of the doe. Post-weaning ADG becomes an important production factor if kids are sold as yearlings or older.

Carcass Characteristics: Carcass characteristics of interest are dressing percentage, ratio of lean to fat and muscle distribution. Carcass characteristics can not be measured on the farm. Good record keeping with traceability of data from a dedicated processing plant should help the meat goat breeder to measurably increase the productivity of the meat goat enterprise.

Productivity Indexes: Several productive and reproductive traits can be combined into an index to give a measure of total productivity.

Advantages of goat keeping

In many parts of the world where the geophysical properties of the terrain are not suitable for other livestock species, goats seem to be the best choice. The role of goats in supplying food to humans has been well stated by many researchers (Devendra, 1985). Based on the accumulated information on goat characteristics, it can be stated that goats have a specific place in the animal agricultural economy of many countries. These characteristics can be summarized in the following points:

1. Goats can withstand heat stress and can endure prolonged water deprivation. They have additionally great adaptability to adverse climatic and geophysical conditions, where cattle and sheep cannot survive.
2. They can efficiently utilize poor quality forage and cover long distances looking for food. Their peculiar feeding habits make it easier to choose diets to meet their requirements.
3. Goats are the most prolific domesticated ruminant. Faster reproduction contributes to the genetic progress that can be achieved and enables their owners to recover quickly.
4. Farmers and pastoralists are increasingly relying on goats as means of survival and a way of boosting their income (Peacock, 2005). The increasing frequency of droughts, with long-term environmental degradation is causing pastoralists to change from cattle or sheep to camels or goats.
5. Overgrazing makes rangelands increasingly suitable for browsing species such as goats.
6. The widespread decline in services supplied by governmental agencies encourages farmers to move from keeping cattle to goats.
7. Goats provide their owners with a broad range of products and socio-economic services and have played an important role in the social life of many people being used as gifts, dowry, in religious rituals and rites of passage (Peacock, 1996).

Goats, especially dairy ones, are an ideal species for poverty reduction and economic development for the poor in developing countries. Several reasons make goats particularly attractive for poverty reduction and improvement of family food security and livelihood of the poor in developing countries:

1. Goats are easily acquired by the poor as they require modest starting capital.
2. They can easily be tended by the weak, women or children.
3. They provide people by valuable nutrients.

4. Many people cannot drink cow milk as they are allergic to it. Several studies indicated that people with cow's milk allergy could tolerate goat's milk (Restani, 2004).
5. The growing demand for goat meat presents an opportunity for goat fattening.

Environmental Concerns

In several countries there is a justified concern about the damaging effect of goats on forests, trees, woodland and grazing. Therefore, goats have been banned in many regions (Çelik and Bayramoĝlu, 2010). Heavy grazing by sheep and goats has led to the destruction of much of the herbaceous and woody vegetation on the non-cultivated land (Albareda, 1955). Atkinson (1964) described how feral goats have modified the vegetation in several New Zealand localities. It was also found that goats, among some other species, had destroyed many plant species and animals depending on them in some islands of the USA (Groombridge, 1992). In Australia, it was reported that goats contributed to environmental degradation (Ministry of Environment and Conservation, 2005). Domesticated goats have been observed to escape easily and to survive and reproduce in the wild. Therefore, the goat population in Australia is mostly feral. These feral goats can cause and contribute to overgrazing, especially in pastoral areas. They are unacceptable in areas dedicated to conserve flora and fauna. The severe damage that goats have caused in some regions is usually associated with high stocking density and mismanagement. Heavy goat damage is usually localized. Goats have a good appetite for and the ability to utilize effectively many trees and shrubs not available or not palatable to sheep and cattle. Therefore, they can be more damaging to perennial vegetation and soil stability. This is greatly realized during drought in arid zones, as goats have a reputation for being good survivors. Clearly, goats require careful management to avoid irreversible damage to the vegetation.

Abstract

This article offers information on the present status of goat populations and their productivity. The overview discusses number of goats in different parts of the world as well as the top countries having goats. The article also reviews the status of goat milk and meat production over the globe. In addition, breeding objectives and genetic improvement programs for milk and meat are discussed giving some examples of the reputable goat breeding projects. Several selection criteria serving the proposed breeding objectives are also suggested. Advantages of goat keeping and the reasons for their expansion are reviewed. Uncontrolled goat populations have contributed to serious environment degradation in several areas in the past, which serves as a reminder that goats require careful management to avoid irreversible damage to the vegetation.

Zusammenfassung

Perspektiven für die Ziegenhaltung in verschiedenen Regionen der Welt

Dieser Beitrag gibt eine Übersicht über die gegenwärtige Situation der Ziegenhaltung in verschiedenen Regionen der Welt und für die Produktion von Milch und Fleisch. Die globale Ziegenhaltung hat in den letzten beiden Jahrzehnten deutlich zugenommen, vor allem in Asien und Afrika, wo sie nicht unwesentlich zur Selbstversorgung ländlicher Familien beitragen. Die Bedeutung von Milch und Fleisch ist dabei sehr unterschiedlich.

Vorzüge der Ziegenhaltung gegenüber anderen Nutztieren werden herausgestellt und Zuchtziele für die Produktion von Milch und Fleisch an unterschiedlichen Standorten kritisch dargestellt. Systematische Zucht wird überwiegend in Europa und den USA betrieben, wobei eine effiziente Produktion von Milcheiweiß im Vordergrund steht. Für die Ziegenhaltung in Entwicklungsländern ist demgegenüber die Anpassungsfähigkeit an ungünstige Umweltbedingungen von allererster Bedeutung. Abschließend wird das Problem der Landschaftszerstörung durch Überbesatz und verwilderte Ziegenbestände eingegangen, das in einigen Fällen zum Verbot der Ziegenhaltung geführt hat.

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100 Years Friedrich-Loeffler-Institut (FLI)

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The Friedrich-Loeffler-Institut, Federal Research Institute for Animal Health, which celebrated its centennial this month, may have been relatively unknown to many colleagues in the global animal industry before German reunion about 20 years ago and the more recent global concern about HPAI. However, it represents the world's oldest virus research institute and has performed research on animal health for 100 years.

On Sunday, 10-10-10, 10:10 a.m., the gates of the FLI opened for the first time in the last 100 years for the general public. Information offered included the work of all eleven FLI institutes located at 7 sites in Germany, the history of the island Riems, and also tours around the new laboratory and animal facilities. About 8.200 people made it to the island, and the feedback has been very positive. According to the saying that "Seeing is believing" this Open Day further increased confidence in the responsible work at FLI and in the biosafety measures applied.

The day ended with a ceremonial act in the city of Greifswald during which the Federal Minister for Agriculture, Ilse Aigner, and the director general of the O.I.E., Dr. Bernard Vallat, amongst others, expressed their appreciation for the work of the FLI and stated their hopes for continued and extended FLI engagements in international networks. The centenary celebrations were completed with an international symposium on "Animal Health in the 21st century" (October 11th-13th) in which also influenza-related topics had a fair share.

Friedrich Loeffler (1852 – 1915), a physician and professor of hygiene at Greifswald University, is best known for his research into diphtheria identifying the causative agent and already postulating that it is not the bacterium itself but a released toxin which causes the disease. Scientifically, the discovery in 1898, jointly with his colleague Paul Frosch, of infectious agents smaller than bacteria was probably even more important and made him one of the founding fathers of virology. Of all viruses we know today they managed to identify the foot-and-mouth disease virus (FMDV), one of the smallest viruses. Due to FMD infections in farms nearby his experimental animal facilities outside Greifswald which could be traced to his experiments, he was ordered, in 1907, to stop FMD research until he could find a place with higher biosafety. For Loeffler, an island was ideal and so he continued his studies on the nearby island of Riems in the Baltic Sea. He notified the imperial authorities that he took up work at Riems on 10-10-1910, the birth date of the institute that carries his name since 1952.

The institute on the island continuously worked on infectious diseases, in particular FMD, and in 1938 developed the first active FMD vaccine. After World War II, a parallel institute was founded in West Germany in Tübingen, designated as the Federal Research Institute for Virus Diseases of Animals. Following the national re-union in 1989, the two institutes were merged together with the Wusterhausen facility into one institution with Riems becoming headquarters in 1997. Following several more phases of organizational rearrangements, the FLI today consists of eleven scientific institutes with branches in Jena (bacteriology), Braunschweig (animal nutrition), Mariensee (farm animal genetics), Celle (animal welfare and husbandry), Tübingen (immunology) and Wusterhausen (epidemiology).

Given the need to relocate other FLI institutes like the immunology and the epidemiology onto the island and realizing the partly historic building fabric of the laboratories, a new construction of laboratories and animal facilities was inevitable. Building activities started in 2008 and progressed rapidly. The new construction, to be completed in 2011, will host 89 laboratories and 163 animal units with different biosafety levels (BSL). Included are labs and facilities for large animals also for BSL 4.

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