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Prof. Dietmar Flock,
Editor

Editorial

Almost 50 years ago, when I was close to finishing my PhD thesis and reading every new issue of “Dairy Science” and other journals in search of the latest publications related to my topic of bull dam selection, my major professor advised me: if you want to finish, ***you have to decide whether you want to read or write*** – in other words: stop reading and hand in your thesis! Since then, I have learned to meet deadlines, and I am happy to acknowledge the help of all authors who submitted their invited paper for this issue in time, which contributes to the quality of editing.

During my active years in the poultry industry, I used to prepare a manuscript for every meeting where I was invited to speak, and often theses papers were published afterwards. The typical speaker in our time has access to a vast number of slides, from which he or she can select a suitable sample for an attractive power-point presentation. For those who can attend such presentations, this is a wonderful way of communication – informative and entertaining at the same time. But there are usually many people with an interest in the subject who cannot attend the meeting for various reasons (time and/or money), and they appreciate a chance to read what has been said.

Students must learn to read (fast) **and** write (professionally) to compete for attractive jobs and to remain competitive during their lifetime. The World Poultry Science Association celebrated its 100th anniversary last year, and several Working Groups of the European Federation of WPSA Branches have prepared review articles on their contributions. In the June issue 2013 of the World Poultry Science Journal, you will find a review of WG 4 (Quality of Eggs and Egg Products), as one example. I often hear that people have “no time” to read. If your time management is optimized, you should not only find time for reading, but to enjoy it - for a lifetime!

Globally successful companies in any business invest a lot in continuous training of their staff and offering internal knowledge to customers. Lohmann Tierzucht recently established the "Global Competence Team" to offer consultancy services on short notice to operations in the poultry industry. For example, a software package developed by Dr. Kühne can be used to analyze egg production records to optimize placement schedules for different conditions anywhere in the world and to suggest alternatives to current practices which should help to increase annual net income. In the current issue, you will find this program applied to take a critical look at the practice of molting.This issue of Lohmann Information offers the following papers as “food for thought”:

1. ***Poultry Eggs and Child Health - a Review*** is based on a paper **Prof. Songül Yalçin** presented in 2011 at the EggMeat Symposium in Leipzig, Germany, and was updated with her co-author **Prof. Suzan Yalçin** for this issue. The authors have accumulated an impressive number of references, details of which may be obtained from the authors. The information based on medical literature confirms that eggs contain many nutrients which are essential for balanced nutrition of pregnant mothers, newborn babies and children through school age.

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2. ***The Development of Poultry Health Research and Training at the University for Veterinary Medicine Hanover, Germany.*** The author **Prof. Otfried Siegmann** is widely known internationally as former head of the Poultry Clinic in Hanover and credited for essential stages in the development of the "TiHo" Poultry Clinic. He also served as president of the German Branch of WPSA (1987-1996) and continues to participate in the annual meetings as honorary member of the board.

3. ***Selection for improved leg health in purebred broiler lines*** – a review by **Dr. Dagmar Kapell**, member of the Aviagen R&D Team. Sound legs have been on the agenda of primary breeders for many years. The author describes how the effectiveness of selection has been systematically improved. Broad breeding goals and appropriate selection indices assure simultaneous progress in all important traits, despite negative genetic correlations. Selection in a highly bio-secure environment was shown to be effective also at the commercial level in the global broiler industry.

4. ***Focus on optimal starting conditions for day-old chicks*** by **Hagen Müller**. Broiler growers in Germany and other countries have learned over the years to keep up with genetic changes in growth potential and feed efficiency, while consumers are getting more concerned about production conditions and drug residues. In this paper the author pinpoints some of the mistakes encountered in practice and shows how optimal chick management can improve performance, minimize treatments and regain consumer support.

5. ***The challenge of cost effective poultry and animal nutrition: Optimizing existing and applying novel concepts*** - by **Dr. Peter Spring**, Applied University of Bern, Switzerland. Feed cost is and will remain the major cost item in farm animal and poultry production. The author reviews the principles of least cost production and offers some useful ideas how current practices may be further improved.

6. ***Determining the optimum replacement schedule for commercial layers: does molting pay off?*** Using general mathematical techniques described by Kühne and Flock 25 years ago, the authors **Robert Schulte-Drüggelte** und **Dr. Hans-Heinrich Thiele**, members of the "Global Competence Team" of Lohmann Tierzucht, review the effect of length of laying period on annual egg income under current conditions of production. Calculations based on production standards for LSL Lite hens in North America and U.S. prices for pullets, feed and eggs show an advantage of about 1 U.S. $ per hen place per year for single cycle flocks kept to 85 weeks compared to molting and a second cycle to 109 weeks of age.

7. ***Longevity of high producing dairy cows: a case study*** by **Prof. Holger Martens**, Physiologist at the Free University Berlin, who has developed a special interest in the conflict between maximum milk yield and longevity in dairy cattle breeding. With his co-author **Christian Bange**, he reports observations from a family farm in Northern Germany with a herd of 145 German Holstein cows as an example that negative correlations can be overcome successfully – if management is focused on health and wellbeing of the herd and pays more attention to lifetime rather than first lactation milk yield.

With kind regards,

Prof. Dietmar Flock,
Editor

Poultry Eggs and Child Health – a Review

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Introduction

Nutritional intakes during childhood should provide for maintenance of current weight and support normal growth and development. Failure to meet the substantial dietary needs in childhood can result in energy and nutrient deficiencies that adversely affect the growth and development process. In addition, impairments in immune functioning, increased morbidity and mortality in childhood can occur. On the other hand, excesses in energy intake or imbalance in nutrient intake also have negative health effects, such as obesity or cardiovascular disease risk factors. Children having unbalanced nutrients will grow up to become stunted, obese and low in academic performance during adulthood. Malnutrition encompasses obesity, stunting, wasting and micronutrient deficiencies. Stunting, severe wasting, and low birth weight due to intrauterine growth restriction together were responsible for 2.1 million deaths (21% of worldwide deaths under 5). Micronutrient deficiencies include iron, zinc, iodine, vitamin A, the B vitamin complex (especially folate and vitamin B12), and vitamin D. Vitamin A and zinc deficiency resulted in about 6% and 4% of under-5 deaths, respectively. Low intakes of micronutrients not only result in the known clinical deficiencies such as anaemia, goitre and eye problems, but also compromise immune function, cognitive development, growth, reproductive performance and work productivity. Therefore, It is important to choose appropriate nutrients to prevent deficiency, to promote adequacy, and to prevent noncommunicable diseases associated with excess intakes (Ahmed et al. 2012, Black *et al.* 2008, Kliegman *et al.* 2011, WHO/FAO 2002).

Because of the rapid rate of growth and metabolic rate during the first years of life, nutrient needs per unit body weight of infants and young children are very high. Given the relatively small amounts of foods that are consumed at 6-24 months, the nutrient density (amount of each nutrient per 100 kcal of food) of the diet needs to be very high. To meet the requirements for nutrients such as iron and zinc, animal-source foods are needed (WHO, 2005). Proteins from animal sources, e.g. meat, poultry, fish, eggs, milk, cheese and yogurt, provide all essential amino acids in adequate amounts and are considered as "complete proteins". It was found that eggs were the lowest cost sources of protein, vitamin A, vitamin B12, iron, zinc and riboflavin. Therefore, eggs provide optimal nutrition at an affordable cost (Drewnowski, 2010).

The Nutritional Contribution of Eggs

Proteins

Eggs are classified as the "food protein group". Eggs contain high quality protein, with 100% of chemical score (essential amino acid level in a food protein divided by the level found in an "ideal" food protein), 97% of egg protein being digestible and 94 % of biologic score (a measure of how efficiently dietary protein is turned into body tissue) (WHO/FAO/UNU 2007, McNamara and Thesmar 2005).

Nutritional requirements for optimal health change throughout our life to meet our needs for growth and development and the physiological challenges and modifiable risks associated with diseases throughout life (WHO/FAO 2002, WHO/FAO/UNU 2007). The nutritional value of eggs and the contribution they make to the diet of infant, toddler, children and adolescents are illustrated by Table 1. The data on the nutritional contents are based on a single medium boiled egg excluding the shell. Overall, 12.6% of the weight of the edible portion of the egg is protein and 50 g edible portion of the egg provides nearly half of the recommended daily allowances (RDA) of protein for children aged 1-3, 33.1% for children aged 4-8, 18.5% for adolescents aged 9-13, 12.1% for boys aged 14-18 and 13.7% for girls aged 14-18.

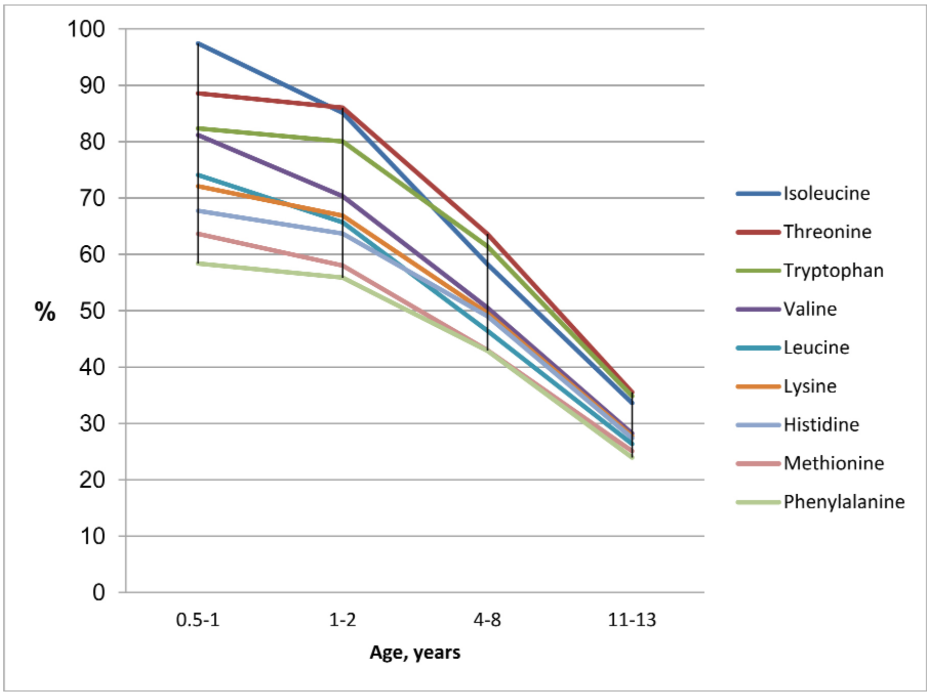
Table 1: Nutrient content of hard-boiled hen eggs in 50 g edible portion without egg shell and contribution to recommended daily intakes for children and adolescents

	Nutrient content (per 50g edible portion)*	Contribution to recommended daily intakes, %**						
		Children			Males		Females	
		6-12 mo&	1-3 y	4–8 y	9–13 y	14–18 y	9–13 y	14–18 y
Water	0.04 L	4.6	2.8	2.2	1.5	1.1	1.8	1.6
Carbohydrates	0.56 g	0.6	0.4	0.4	0.4	0.4	0.4	0.4
Fat	5.31 g	17.7						
Linoleic acid &	0.59 g	12.9	8.5	5.9	5.0	3.7	5.9	5.4
α-Linolenic acid &	0.02 g	3.6	2.6	2.0	1.5	1.1	1.8	1.6
Protein	6.29 g	57.2	48.4	33.1	18.5	12.1	18.5	13.7
Vitamin A	75.0 µg	15.0	25.0	18.8	12.5	8.3	12.5	10.7
Vitamin D	1.10 µg	11.0	7.3	7.3	7.3	7.3	7.3	7.3
Vitamin E	0.52 mg	10.4	8.7	7.4	4.7	3.5	4.7	3.5
Vitamin K	0.20 µg	8.0	0.7	0.4	0.3	0.3	0.3	0.3
Thiamin	0.03 mg	11.0	6.6	5.5	3.7	2.8	3.7	3.3
Riboflavin	0.26 mg	64.3	51.4	42.8	28.6	19.8	28.6	25.7
Niacin	0.03 mg	0.8	0.5	0.4	0.3	0.2	0.3	0.2
Pantothenic Acid&	0.70 mg	38.8	35.0	23.3	17.5	14.0	17.5	14.0
Vitamin B6	0.06 mg	20.3	12.2	10.2	6.1	4.7	6.1	5.1
Folate	22.0 µg	27.5	14.7	11.0	7.3	5.5	7.3	5.5
Vitamin B12	0.56 µg	112.0	62.2	46.7	31.1	23.3	31.1	23.3
Choline&	146.9 mg	97.9	73.5	58.8	39.2	26.7	39.2	36.7
Calcium	25.0 mg	9.6	3.6	2.5	1.9	1.9	1.9	1.9
Copper	7.00 µg	3.2	2.1	1.6	1.0	0.8	1.0	0.8
Iron	0.60 mg	5.5	8.6	6.0	7.5	5.5	7.5	4.0
Magnesium	5.00 mg	6.7	6.3	3.8	2.1	1.2	2.1	1.4
Manganese&	0.01 mg	2.2	1.1	0.9	0.7	0.6	0.8	0.8
Phosphorus	86.0 mg	31.3	18.7	17.2	6.9	6.9	6.9	6.9
Selenium	15.4 µg	77.0	77.0	51.3	38.5	28.0	38.5	28.0
Zinc	0.53 mg	17.7	17.7	10.6	6.6	4.8	6.6	5.9
Potassium&	0.06 g	9.0	2.1	1.7	1.4	1.3	1.4	1.3
Sodium&	0.06 g	16.8	6.2	5.2	4.1	4.1	4.1	4.1

The data followed by symbol "&" were "Adequate Intakes (AIs)". Other data were "Recommended Dietary Allowances (RDAs)"
* Egg, whole, cooked, hard-boiled, 50 g edible portion without egg shell (Adapted from USDA, 2012).
** Calculated from Food and Nutrition Board, Institute of Medicine: 2005

Egg protein is a rich source of all essential amino acids (EAAs) in optimal composition. The EAAs in an egg contribute more than 60 % of the dietary requirement for children aged 6-11 months, nearly half (43-64 %) of dietary requirement for children aged 4-8 years, 24-35 % for children aged 11-13 years (Figure 1).

Figure 1. The contribution of egg for daily requirement of essential amino acids by age, % (Calculated by WHO/FAO/UNU 2007 and USDA, 2012).



Fat

Eggs are low in fat (5.3 g fat/one egg). Overall, 50 g edible portion of a boiled egg has an energy value of 78 kcal (324 kj) and the consumption of one egg daily would contribute only around 5 % of the average energy requirement of a child aged 6 years in a 1400-1600 kcal diet (Kliegman *et al.* 2011, USDA 2012). Most of an egg's total fatty acid composition is monounsaturated (approximately 38%). About a further 13% is polyunsaturated and only 31% is saturated. One egg provides 8.5% of dietary requirement (adequate intake, AI) of linoleic acid for children aged 1-3, 5.0% for boys aged 9-13 and 5.9% for girls aged 9-13 (Table 1). One egg provides 2.6% of AI of α-linolenic acid for children aged 1-3, 1.5% for boys aged 9-13 and 1.8% for girls aged 9-13. Eggs have no trans-fatty acids. Eggs are one of the richest sources of dietary cholesterol, providing 187 mg per 50 g edible portion of boiled egg (USDA 2012).

Vitamins

Eggs contain most of the recognized vitamins with the exception of vitamin C. The egg is a source of all B vitamins. It is a particularly rich source (>10% RDA) of vitamins B12, riboflavin, pantothenic acid and choline thoughout life. One egg provides all requirements of vitamin B12 for infants aged 6-12 months, three-fourth of RDA for children aged 1-3 years and more than half of RDA for children aged 4-8 years. One egg provides nearly half of the requirement of riboflavin up to 9 years of age (Table 1). One egg contains 146.9 mg of choline which is nearly all of AI for infants and three-fourth for children aged 1-3 years and more than half for children aged 4-8 years and two-third of adolescents. Eggs are also rich (>10% RDA) in folate and vitamin B6 for children younger than 9 years. One egg provides more than 20% of the RDA of folate and vitamin B6 for children aged 6-12 months. The egg is also a source of the fat-soluble vitamins A, D, E and some vitamin K. One egg provides around one-fourth of RDA of vitamin A for children aged 1-3.

Minerals

The egg is a highly nutritious food containing several minerals. Eggs contain many of the minerals that the human body requires for health and they are naturally low in salt. One egg (50g edible portion) is a good source (>25% RDA) of selenium throughout life and a source (>10% RDA) of zinc and phosphorous for children up to 9 years of age (Table 1). Eggs provide useful amounts of iron and zinc, which are often low in many children's diets. In particular eggs are an excellent source of iodine (25 µg/egg) (FSA, 2002). One egg provides 48% of RDA of iodine for children aged 4-8 and 36% for children aged 9-13.

Antioxidants

The egg is a source of highly bioavailable forms of the carotenoids, lutein and zeaxanthin. They are antioxidant-like compounds. One egg has been found to provide 177 µg of these carotenoids (USDA, 2012).

Manipulation of egg contents

The enrichment of hen eggs with additional micronutrients would provide new niche markets by improving the nutritional status of children. Enrichment of poultry eggs might be advantageous over the use of supplements because of either low compliance or increased risks of toxicity when relying on supplements, and there are advantages in marketing "naturally" enriched foods (McNamara and Thesmar, 2005; Yalçin *et al.* 2004; Yalçin *et al.* 2009). Some commercially available nutrient enriched eggs contain increased amounts of omega-3 fatty acids, vitamin E, selenium and lutein. Vitamin E levels in eggs have been increased up to 10-25 fold, lutein up to 10 fold, selenium up to 5-9 fold, iodine up to 2-3 fold. Fortified eggs could further yield significant amounts of RDA of n-3 PUFA, DHA, vitamin A, vitamin E, iodine and selenium for children (Shapira, 2009; McNamara and Thesmar, 2005).

Predicted impacts of egg nutrients on child health

Eggs contain essential nutrients and energy to prevent nutritional deficiencies and excesses and provide the right balance of fat and protein to reduce risks for chronic disease (Ruxton *et al.* 2010). High quality protein of eggs has benefits for children and adolescents in aiding growth and development. Decreased egg consumption has been correlated with protein malnutrition in underdeveloped countries (Sullivan *et al.* 2006). Athletes can benefit from higher protein intakes for preservation of lean muscle mass during weight loss (Mettler *et. al.* 2010).

Feeding infant formula containing egg phospholipids was found to reduce the incidence of necrotizing enterocolitis, suggesting that one or more of the compounds of egg phospholipids may enhance the immature intestinal functions of infants (Carlson et al. 1998).

Makrides *et al.* (2002) showed that breast-fed infants who received docosahexaenoic acid (DHA) enriched egg yolks 4 times per week from 6 to 12 months had higher red cell DHA levels at 12 months than did those fed standard egg yolks or no egg yolks. Hoffman *et al.* (2004) reported that breast-fed infants receiving foods containing egg yolk enriched with DHA during 6-12 mo of life had an 83% elevation in red cell DHA levels resulting from an approximately 2-fold greater intake of DHA compared with unsupplemented infants. DHA-supplemented infants had more mature visual evoked potential (VEP) acuity (increase in visual acuity resolution) than control infants at 9 and 12 mo of age. Infants with higher levels of red cell DHA had better visual acuity. Kannass *et al.* (2009) investigated the relationship between maternal DHA levels at birth and toddler free-play attention in the second year. They reported that higher maternal DHA status at birth was associated with enhanced attentional functioning during the second year. Toddlers whose mothers had high DHA at birth exhibited more total looking and fewer episodes of inattention during free-play than toddlers whose mothers had low DHA at birth. These findings are consistent with evidence suggesting a link between DHA and cognitive development in infancy and early childhood (Birch *et. al.* 2007).

The supplementation of infant formulas with egg yolk lipids has been suggested to more closely resemble mother's milk, and Makrides *et al.* (2002) found that while providing essential nutrients, the yolk lipids did not increase plasma cholesterol.

High intake and plasma level of choline in the mother seems to afford reduced risk of neural tube defects (Ueland 2011). Previously, Shaw *et al.* (2004) found that women in the lowest quartile for dietary choline intake had four times the risk of giving birth to a child with a neural tube defect, compared with women in the highest quartile of intake. Konstantinova *et al.* (2008) reported that plasma free choline was positively related to intake of eggs, but not to other choline-rich food items in a Norwegian study. Suarez *et al.* (2012) found that increased folate intake had a protective effect and low serum B12, high serum homocysteine levels and obesity independently contributed to risks for neural tube defects. Chandler *et al.* (2012) reported that higher intakes of folate, thiamin, iron and vitamin A were associated with decreased risk of anencephaly among some ethnic and clinical groups. In addition higher intakes of thiamin, riboflavin, vitamin B6, vitamin E, niacin and retinol were associated with decreased risk of spina bifida. Given a good source for these nutrients, eggs can play important roles in preventing neural tube defects and in the brain development of infants.

Methyl groups for DNA methylation are mostly derived from the diet and supplied through one-carbon metabolism by way of choline, betaine, methionine or folate, with involvement of riboflavin and vitamins B6 and B12 as cofactors. Given the plasticity of DNA methylation in the developing embryo and the established role of one-carbon metabolism in supporting biological methylation reactions, it is plausible that alterations in maternal one-carbon nutrient availability might induce subtle epigenetic changes in the developing embryo and fetus that persist into later life, altering the risk of tumorigenesis throughout life. Retrospective studies investigating the effect of famine or season during pregnancy indicate that variation in early environmental exposure in utero leads to differences in DNA methylation of offspring (Ciappio *et al.* 2011, Dominguez-Salas *et al.* 2012)

Choline has been shown to play an important role in the reduction of homocysteine in the blood (Molloy *et al.* 2005). Elevated maternal homocysteine concentrations are a risk factor for several adverse pregnancy events, including preeclampsia, prematurity and very low birth weight, and have been suggested to have an important role as a marker of pregnancy complications and adverse pregnancy outcomes (Vollset *et al.* 2000, Zeisel and Costa 2009). Similarly, Jiang *et al.* (2013) reported that supplementing the maternal diet with extra choline may improve placental angiogenesis and mitigate some of the pathological antecedents of preeclampsia.

Vitamin B12 works with folate in DNA synthesis and myelin formation and deficiency causes megaloblastic anemia (Stabler, 2013). Vitamin A is essential for growth and eye health (Kliegman *et al.* 2011).

Research evaluating the plasma iron and transferrin saturation in 6-12 month-old children indicated that infants who ate egg yolks had a better iron status than children who did not (Makrides *et al.* 2002). Johner *et al.* (2012) found that milk, salt and eggs were the main contributors to iodine intakes in the diets of 221 German preschoolers aged between 3 and 6 years. Also, the egg is a significant source of phosphorus, required for bone health, and provides some zinc, important for wound healing, growth and fighting infection (Kliegman 2011, USDA 2012).

Eggs and obesity

During the past decades, the number of children who are overweight has increased, which has major health consequences. Being overweight or obese substantially increases the risk of acute health problems and chronic disease. Overweight and obese children and teenagers are more likely to have risk factors for diabetes, cardiovascular disease and liver disease than those who are not overweight (Kliegman 2011). The increase in childhood overweight was due to overconsumption of energy-dense, nutrient-poor foods and beverages and low physical activity patterns (Nicklas *et al.* 2008; Kliegman *et al.* 2011, WHO/FAO 2002). One egg is low in kj, providing around 5 % of the average energy requirement of a child aged 6 years in a 1400-1600 kcal diet, while providing one-third of daily protein requirement (USDA 2012, Kliegman *et al.* 2011). A review of dietary protein in the regulation of food intake has shown that protein makes a stronger contribution to satiety than carbohydrates and fat, and also causes greater suppression of food consumption (Anderson and Moore 2004). The protein in eggs may protect against weight gain by helping to promote satiety and suppress appetite. Consequently, obese children might experience reduced hunger on a higher-protein low-kj diet resulting in better compliance. In addition, egg intake slows the rate of gastric emptying, resulting in a flatter blood glucose response and a lower insulin response (Pelletier *et. al.* 1996). Some researchers concluded that moderate consumption of eggs (one to two eggs per day) should be actively encouraged as part of an energy restricted, weight-losing dietary regimen (Lee and Griffin. 2006). Similarly, Leidy *et al.* (2013) reported that the consumption of "egg- and beef-rich (35 g protein) breakfast" reduced evening snacking of high-fat foods, reduced daily ghrelin and increased daily peptide YY concentrations compared with "breakfast skipping". "High protein breakfast" was found to lead to reductions in hippocampal and parahippocampal activation compared among adolescents with "non-protein breakfast". This study shows that breakfast, rich in protein, might be a useful strategy to improve satiety, reduce food motivation and reward, and improve diet quality in overweight or obese teenage girls.

Eggs and heart health

Previously, there were some controversies regarding the role of dietary cholesterol in determining blood cholesterol levels and coronary heart disease (CHD). However, most studies have shown that saturated fat, not dietary cholesterol, is the major dietary determinant of CHD in healthy populations (Fernandez 2012, Gray and Griffin 2009; Nakamura et al. 2006; Qureshi *et al.* 2007). Egg intake promotes the formation of large LDL and HDL subclasses, which are less atherogenic (Fernandez 2010). Ballesteros et al. (2004) evaluated the effects of consuming two whole eggs per day compared to egg whites only, on plasma lipids and the atherogenicity of the LDL particle in Mexican children aged 10–12 y. They reported that the increases in plasma cholesterol due to dietary cholesterol was present in 1/3 of the children and was associated with increases in both LDL and HDL with no alterations in the LDL-C/HDL-C ratio and there was a shift of LDL size to a less atherogenic particle. Merkens *et al.* (2004) reported an increase in plasma LDL and HDL as a potential beneficial effect of eggs in children suffering from Smith-Lemli-Opitz syndrome, a condition of impaired cholesterol synthesis. In addition, some nutrients such as long chain omega-3 fatty acids, arginine, lutein and zeaxanthin found in eggs also may be associated with protection from CHD or its risk factors (Fernandez 2010, McNamara and Thesmar 2005, Ruxton *et al.* 2010). Recently, Voutilainen *et al.* (2013) also found that regular consumption of eggs did not affect carotid plaque area or risk of acute myocardial infarction in Finnish men.

Immunomodulation

It is well documented that hen eggs contain numerous proteins, peptides and lipids that exert beneficial bioactive effects (Kovacs-Nolan *et al.* 2005). Egg white proteins, including lysozyme, ovomucin, ovalbumin and ovotransferrin, which collectively make up around 73% of total egg white composition, have demonstrated potent immunemodulating activity, antimicrobial, antiviral, anticancer and protease inhibiting activities (Kovacs- Nolan *et al.* 2005), When combined with immunotherapy, lysozyme was effective in improving chronic sinusitis (Asakura et al. 1990) and in normalizing humoral and cellular responses in patients with chronic bronchitis (Sava 1996).

Egg yolk components have been shown to possess a number of novel biological functions including antiadhesive, antimicrobial and antioxidant activity (Kovacs-Nolan *et al.* 2005). Egg yolk antibodies, immunoglobulin Y [IgY] is the functional equivalent of IgG, the major serum antibody in mammals. IgY has been produced against a number of bacteria and viruses and has been shown to bind to and inhibit the infection and disease symptoms, in vitro and in vivo, of gastrointestinal pathogens such as human and bovine rotavirus, bovine coronavirus, *E. coli, Salmonella spp., Yersinia ruckeri, Edwardsiella tarda, Helicobacter pylori*, porcine epidemic diarrhea virus, and infectious bursal disease virus, as well as *S. aureus* and *P. aeruginosa* (Kovacs-Nolan and Mine 2004). The stability of IgY in the orogastrointestinal tract and its safety profile has been well-documented. Therefore, IgY can be used to confer passive immunity as an inexpensive non-antibiotic alternative for the prophylaxis and treatment of a wide variety of infectious diseases. IgY has been used in the treatment or prevention of dental caries, periodontitis and gingivitis, gastritis and gastric ulcer, oral thrush and infant rotavirus diarrhea (Rahman *et. al.* 2013). IgY against *S. mutants* has been shown to prevent oral colonization by mutants streptococci and to reduce dental caries development in humans (Hatta et al. 1997; Nguyen *et al.* 2011). In human studies, orally administered anti-*P. aeruginosa* IgY was found to prevent *P. aeruginosa* colonization in the lungs of cystic fibrosis patients, indicating its use as an alternative to antibiotic treatment (Kollberg *et al.* 2003), and the suppression of *H. pylori* infection in humans was observed following the consumption of a yogurt beverage fortified with IgY against H. pylori urease enzyme (Horie *et al.* 2004). Rahman *et al.* (2012) evaluated the effect of hyperimmune Ig Y (Rotamix IgY) against human rotavirus among pediatric patients receiving standard supportive treatment for rotavirus-associated diarrhea mostly with an enteric non-cholera copathogen in a hospital setting. Rotamix IgY had statistically significant reduction in mean oral rehydration fluid intake ($p=0.004$), mean duration of intravenous fluid administration ($p=0.03$), mean duration of diarrhea from day of admission ($p<0.01$) and mean duration of rotavirus clearance from stool from day of admission ($p=0.05$). Using oral Rotamix IgY for rotavirus-infected children mostly with non-cholera enteric pathogen co-infection appears to be a promising, safe and effective adjunct to management of acute diarrhea in pediatric patients.

Long-term effects of early-life nutrition on adulthood disease susceptibility

Childhood is the best time to establish healthful dietary habits through adulthood. In addition, healthy and balanced nutrient intake during childhood prevents some noncommunicable disease of adults (Kliegman *et al.* 2011, WHO/FAO 2002). Key nutrients found in eggs, such as vitamin D, vitamin B12, folate, selenium, choline, lutein and zeaxanthin, have been associated with disease prevention (Ruxton *et al.* 2010; McNamara and Thesmar 2005)

The egg is one of the few food sources that contain high concentrations of choline. People whose diets supplied the highest average intake of choline (>310 mg of choline daily, found in egg yolk and soybeans), had at least 20% lower levels of inflammatory markers (22% lower concentrations of C-reactive protein, 26% lower concentrations of interleukin-6, 6% lower concentrations of tumor necrosis factor alpha) than subjects with the lowest (<250 mg/day) average intakes (Detopoulou *et al.* 2008). Each of these markers of chronic inflammation has been linked to a wide range of conditions including CHD, osteoporosis, cognitive decline and Alzheimer's, and type-2 diabetes.

A two-stage case-control study showed that consumption of choline and betaine is inversely associated with the risk of breast cancer and the association of choline intake with breast cancer risk is probably modified by folate intake (Zhang *et al.* 2013).

Lutein and zeaxanthin may reduce the degree of oxidation or minimize the resulting damage by decreasing the permeability of the membrane to oxygen. They have been shown to help in the prevention of age-related macular degeneration, a leading cause of blindness in the elderly, and have been associated with lower risk of cataract extraction (Ma and Lin 2010, Solebo *et al.* 2008). Studies have reported significant increases in plasma levels of lutein and zeaxanthin when patients eat at least one egg daily for five weeks (Handelman *et al.* 1999, Goodrow *et al.* 2006). A study by Wenzel *et al.* (2006) developed this further by identifying that eating six eggs weekly for 12 weeks raised serum zeaxanthin levels and increased macular pigment optical density.

An increased intake of omega-3 fatty acids is known to reduce the risk of heart disease, some inflammatory and autoimmune disorders including rheumatoid arthritis and emerging evidence in the treatment of depression and inflammatory bowel disease (Ruxton *et al.* 2010, Kovacs- Nolan *et al.* 2005),

Interestingly, Blesso *et al.* (2013) reported that incorporating daily whole egg intake (3 eggs/day) into a moderately carbohydrate restricted diet provides further improvements in the atherogenic lipoprotein profile and in insulin resistance in individuals with metabolic syndrome.

Healthy eating guidelines for children

When to introduce eggs

In 2001, the World Health Organization (WHO) recommended exclusive breast feeding until 6 months (26 weeks) of age. At about 6 months babies are ready to move on to a complementary food containing eggs (WHO 2002). The European Society for Gastroenterology, Hematology and Nutrition (ESPGHAN) Committee on Nutrition and the American Academy of Pediatrics (AAP) have stated that there is no conclusive evidence supporting delayed introduction of eggs into the infant diet beyond six months of age (Agostoni *et al.* 2008; Greer *et al.* 2008), with the latter suggesting such a delay may even be disadvantageous in prevention of allergy.

Some countries recommend introducing eggs at 4-6 months, whereas other countries recommend 9-12 months. The suggested age for the introduction of egg whites also differs considerably from 4 to 6 months until 9 or 12 months (Israel MOH, 2009; Lin *et al.* 2011, Agostoni *et al.* 2008).

How often and how much to give

The WHO and the Pan American Health Organization (PAHO) recommend that meat, poultry, fish, or eggs should be eaten daily, or as often as possible because they are rich sources of many nutrients such as iron and zinc (Dewey and Lutter 2003; WHO, 2002). The WHO, the National Heart Foundation of Australia, British Heart Foundation, the Heart and Stroke Foundation of Canada and the Irish Heart Foundation, have not put a limit on the number of eggs consumed (Anderson *et al.* 2013; Graham *et al.* 2007; Fernandez and Calle 2010, National Heart Foundation of Australia 2009). The National Heart Foundation of Australia found that up to six eggs a week can be included as part of a healthy balanced diet that is low in saturated fat without increasing the risk of heart disease.

Egg consumption was recommended in Food Based Dietary Guidelines of Thailand, Philippines, China, South Africa, and Vietnam. One of Nine Thai food based dietary guidelines stated that “A regular consumption of fish, lean meat, eggs, legumes and pulses is recommended and eggs may be taken by children every day, while adults can take 3-4 eggs” weekly (Sirichakwal *et al.* 2011). The California food guide contains one egg per day; there is no specific statement for eggs in Japan and Malaysia (Hop *et al.* 2011). Clover with four leaves has been used in Turkey as a food guide (The Ministry of Health of Turkey, 2006). One leaf of clover belongs to the “meat, eggs, legumes” group. In this food guide, daily egg consumption is recommended.

Eggs given to babies or toddlers should be cooked until both the yolk and the white are solid in any fashion: boiled, scrambled, poached or in an omelet.

Religious and vegetarian preferences

The main dietary rules differ between world religions. Most Christians, Sikhs, Muslims and Buddhists eat eggs. The consumption of eggs differs in Hindu and Buddhist and Rastafarian populations. Strict Hindus and Sikhs do not eat eggs, meat, fish and some fats. Some Rastafarians are vegan. Jewish people do not eat eggs with blood spots (BTEC 2006).

A vegetarian diet can lead to low intake of key nutrients such as protein, vitamin B12, selenium, iodine, iron and omega-3s. Lacto ovo vegetarians do not eat meat, poultry or fish, but will eat eggs, and eggs can play a significant role in helping address these potential shortfalls (BTEC 2006).

High risk infants with family history of allergy

It used to be thought that avoidance of foods with documented allergenic potential may delay or prevent some food allergy and atopic dermatitis in high-risk infants with a strong family history of allergy. However, there is no convincing scientific evidence that avoidance or delayed introduction of potentially allergenic foods, such as fish or eggs, reduces allergies, either in infants considered at increased risk for the development of allergy or in those not considered to be at increased risk (Agostoni *et al.* 2008, WHO 2005, Cattaneo *et. al.* 2011).

For this reason, WHO, ESPGAN and AAP concluded that there was no convincing evidence that delaying the introduction of foods beyond 6 months of age had a protective effect on the development of atopic disease, which also included foods that are considered to be highly allergenic, such as fish, eggs and foods containing peanut protein (Greer *et al.* 2008).

Egg allergy is one of the most prevalent food allergies in children (Venter and Arshad 2011). The estimated prevalence varies between 0.5% and 5% in early childhood, less than 0.5% in older children and adults (Tey and Heine 2009). A more recent study suggested that egg allergy is more persistent, predicting resolution in 4% by age 4 years, 12% by age 6 years, 37% by age 10 years, and 68% by age 16 years (Savage *et al.* 2007). In general, the prognosis for children with egg allergy is good (Tey and Heine 2009). Because most children outgrow their egg allergy, periodic reevaluation is recommended. In milder cases advice will be needed after a symptom-free period, so that the careful reintroduction of eggs can be considered, but only with medical support. Prognostic indicators for the development of tolerance to egg include lower level of egg-specific IgE, faster rate of decline of egg-specific IgE level with time, earlier age at diagnosis, milder symptoms, and smaller skin test wheal sizes (Shek *et al.* 2004, Lemon-Mule *et al.* 2008, Ford and Taylor 1982). People who are tolerant to extensively heated egg may be more likely to outgrow the egg allergy (Lemon-Mulé et al. 2008), while those who are allergic to extensively heated eggs are more likely to have severe, and probably lifelong, egg allergy (Caubet and Wang 2011).

It has been observed that more than half of the infants who develop egg allergy begin to have symptoms within minutes of being given an egg. The use of eggs in cakes, custard, mayonnaise and some pasta is well known; their use in bread, in the glazes added to buns or pies, and in some confectionery may not be so obvious. Therefore, food labeling rules are required for prepacked foods to show clearly if they contain egg. However, there are many foods and products that are not covered by FDA allergen labeling laws, so it is still important to know how to read a label for egg ingredients (KFA's Medical Advisory Team 2009).

Salmonella-caused food poisoning

Health safety concerns about eggs center on salmonellosis (salmonella-caused food poisoning). Salmonella from the chicken's intestines may be found even in clean, uncracked eggs. Eggs should be kept refrigerated to prevent deterioration in yolk membrane permeability and minimize growth of any micro-organisms that may be present. Eggs should be stored separately from other foods, preferably in the egg box. Eggs should be brought to room temperature before cooking. Cooked egg dishes should be eaten as soon as possible after cooking and, if not for immediate use, should be stored in the refrigerator. Hands should always be washed before and after handling shell eggs. Salmonellosis is a common cause of food poisoning and is particularly associated with consumption of raw eggs. To avoid salmonella, eggs should be cooked so both white and egg are solid, firm. Properly cooking eggs to a temperature of 63°C for 3 min will destroy salmonella enterica present in an egg. Recipes containing eggs mixed with other foods should be cooked to an internal temperature of 160°F (71°C). Soft-cooked, sunny-side up or raw eggs carry salmonellosis risk. Hard-boiled, scrambled, or poached eggs do not (McNamara and Thesmar 2005; US FDA 2011).

Summary and Conclusion

A healthy, balanced diet and good nutrition are the building blocks of life. Failure to meet the substantial dietary needs and giving unbalanced nutrients in childhood can result in energy and nutrient deficiencies that adversely affect the growth and development process. As a result, these children, having malnutrition (wasted, stunted or obese), impairments in immune functioning, increased morbidity and mortality, might grow up with poor academic performance and short stature. Eggs contain essential nutrients and energy to prevent nutritional deficiencies and excesses and provide the right balance of fat and protein to reduce risks for chronic disease. This article reviews current literature about the impact and value of egg nutrients in child nutrition and health.

The nutrient density of eggs and biological properties of egg components make them a valuable contributor to the overall nutritional balance of the diet and, as an economical source of high quality protein, an important component in the diets of growing children.

Zusammenfassung

Eier und ihre Bedeutung für die Gesundheit von Kindern

Gesunde, ausgewogene Nahrung und gute Ernährung sind die Bausteine des Lebens. Mangelhafte und unausgewogene Ernährung in der Kindheit kann die körperliche und geistige Entwicklung beeinträchtigen. Mangelhaft ernährte Kinder kümmern, bleiben klein oder verfetten, haben ein unterentwickeltes Immunsystem, sind anfällig für Krankheiten und Sterblichkeit und können schwache Leistungen und geringe Körpergröße in der Schule zeigen. Eier enthalten essentielle Nährstoffe und Energie, und ein ausgewogenes Verhältnis von Fett und Eiweiß Energie kann helfen, Risiken chronischer Krankheiten zu reduzieren. In dieser Literaturübersicht wird die Bedeutung von Eiern für eine gesunde Ernährung von Kindern deutlich gemacht. Aufgrund ihrer Nährstoffdichte und günstigen biologischen Eigenschaften von Komponenten sind Eier ein wertvoller und wichtiger Bestandteil einer ausgewogenen Diät und preiswerte Quelle von hochwertigem Eiweiß für die Ernährung wachsender Kinder.

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The Development of Poultry Health Research and Training at the University for Veterinary Medicine Hannover, Germany

O. Siegmann

Introduction

The University of Veterinary Medicine Hannover is one of five University institutions in Germany serving the complex needs of our society for information on animal health. Its history goes back to the *"Royal Medical Horse School"*, which was founded in 1778. Since 2003 it is organized as a foundation, has a President and a Senate and is continuously challenged to acquire and allocate financial resources to meet the changing demands for education, research and customer service for all species of animals as well as quality and safety of food from animal sources. Located close to the center of animal and poultry production in the State of Lower Saxony, this Institution has a long history of helping to answer questions related to animal health.

Before addressing the special field of poultry diseases, a summary of current staff in all institutes and working groups summarized from the latest directory (9) may give an impression of the specialization and complexity of the organization (table 1).

Table 1: Organizational units of the Foundation with current staff (2012 directory)

No.	Organizational Unit
103	Administration
16	Library
21	General University Services
25	Clinic for Poultry
32	Clinic for Pets, Reptiles, Fancy and Wild Birds
33	Clinic for Pigs, Sheep and Goats, Forensic Medicine and Ambulatory Clinic
85	Clinic for Small Animals
65	Clinic for Horses
59	Clinic for Cattle
33	Anatomic Institute
25	Institute for Biometrics, Epidemiology and Data Processing
61	Institute for Food Quality and Food Safety
28	Institute for Food Toxicology and Chemical Analysis
34	Institute for Microbiology
15	Institute for Parasitology
10	Institute for Parasitology, Section Fish Diseases and Fish Production
37	Institute for Pathology
46	Institute for Pharmacology, Toxicology and Galenics
31	Institute for Physiology
20	Institute for Physiological Chemistry
10	Institute for Reproductive Biology
23	Reproduction Unit of the Clinics
17	Institute for Animal Nutrition
17	Institute for Hygiene, Animal Welfare and Ethology of Farm Animals
18	Institute for Animal Ecology and Cell Biology
11	Institute for Animal Ecology and Cell Biology, Working Group Cell Biology
6	Institute for Animal Welfare and Animal Behavior
23	Institute for Animal Breeding and Genetics
44	Institute for Virology
31	Institute for Terrestrial and Aquatic Wild Animals, Büsum
16	Institute for Terrestrial and Aquatic Wild Animals, Hannover
25	Institute for Zoology
3	Working Group History of Veterinary Medicine and Domestic Animals

9 Working Group Immunology
6 Working Group General Radiology and Medical Physics
22 Satellite Station for Epidemiology, Bakum
11 Training and Research Station, Ruthe

Early history of Poultry Research

The history of poultry disease research in Hannover can be traced back to 1834, when facilities of the Royal Medical Horse School were first used to investigate diseases of commercial and fancy poultry species as well as game and wild birds. The first publication on poultry diseases was on fowl pest (Künnemann 1902), and many subsequent papers from different areas of research reflect the growing interest in poultry, its products and diseases. The first doctoral thesis was on Colibacillosis (Hempel 1912) and describes the reaction of the gastro-intestinal tract of healthy chickens to infections with Coli-Typhus bacteria. The first course offered to students was by Prof. Krüger (1930) on “Anatomy of Poultry and Research Mammals”.

Institute for Animal Hygiene and Poultry Diseases

The basis for today’s Poultry Clinic in Hannover was laid in 1949 when the Senate decided to reorganize the existing clinics according to species. Among other institutes, departments for animal hygiene and poultry diseases were planned. In 1955 the Senate decided to combine these two subject areas and in 1960 hired Prof. Irmgard Gylstorff, the first woman as head of the department.

Despite the provisional situation and limited space in the Chemical Institute, initially modest staff and research funding, remarkable scientific activities developed under her guidance. Since housing facilities for research animals which were not available in the old University quarters, students had to acquire diagnostic experience from ambulatory extension service in commercial poultry farms, and a laboratory was established for diagnostics and treatment of fancy and wild birds. Theory was taught in lectures on hygiene and internal medicine, and courses for further education were organized in cooperation with other University organizations. With her profound knowledge and immense energy, Prof. Gylstorff established a strong position for poultry pathology at the Veterinary University Hannover, which became recognized nationally and internationally. When the Veterinary Faculty of the University Munich established a department for poultry pathology, she accepted the call to become the first chairperson of the department.

Poultry Clinic

During the 1960 the domestic poultry industry in Germany went through a period of dramatic changes and presented a range of challenges for veterinarians. The Senate reacted with the decision to split the institute and establish separate chairs for animal hygiene and poultry diseases. The author of this article Prof. Siegmann became the first chairman of the Institute for Poultry Diseases in 1966.

Based on the conditions negotiated at the beginning and recommendations of the German Scientific Council, the present Poultry Clinic was gradually built up. In 1968 the first part of a new quarantine unit was built, and two years later it was completed for in vivo disease studies and the maintenance of SPF flocks. In 1974 a new complex was built for three institutes on two floors, with excellent conditions for research projects which depend on close cooperation between colleagues specialized in different areas within the poultry clinic. Research, education and extension service benefit from this structural organization (Fig. 1).

The Policlinic for Fancy and Wild Birds remained at the old location, to keep it easily accessible by public transport to meet the growing demand. The move into rooms of the old apothecary and later on pathology improved the working conditions substantially and contributed to the recognition of this team of experts.

The laboratory equipment was continuously expanded and modernized to keep up with new developments, notably after Prof Neumann became head of the clinic in 1992 and new techniques for molecular genetics and immunological analyses were added.

At the end of the 1970s the staff of the poultry clinic had 28 employees, including 10 with academic degrees. In addition, a variable number of graduate students and guest scientists from different countries were always actively involved in research projects and contributed to a lively academic environment. Details who was involved in which project is documented in annual records of the University until 2008/09 (4), but unfortunately discontinued since then. The same goes for lectures offered each year, which provides a convenient basis for anybody interested in the changing priorities during this period of time. Diseases of poultry are a required course for all veterinary students since 1967.

Research reports from the Veterinary University of Hannover are listed annually (8) and add to more than 800 scientific publications, 150 dissertations and 6 habilitation theses since 1960 published by the Poultry Clinic staff. The topics of these publications reflect the range of subjects covered during the past decades.

Compendium of Poultry Diseases

In view of the continuously growing information on etiology, diagnostics, prophylaxis and therapy it is impossible to include everything in university lectures which students need for their professional future, and students will hardly find time to keep up with new information from special literature. Realizing this demand for basic information, Siegmann (1971) published a “Compendium of Poultry Diseases”, mainly for students of veterinary science, to assist them in acquiring the necessary basic understanding of poultry diseases. The 7th edition was recently published (7).

The circulation of the Compendium increased over the years and benefited from updates contributed by many co-authors: Hinz, Kaleta and Lüders, Hannover (3rd ed.), thereafter by Monreal, Berlin, and Kösters, Munich. For the 6th edition, Neumann became co-editor, and 35 contributing authors from German speaking veterinary institutions in research, veterinary practice and administration cover all relevant aspects of poultry diseases. Originally planned to assist veterinary students, this Compendium has become the standard on poultry diseases in German.

Bi-annual Discussions among Poultry Disease Experts

To bring colleagues from the Poultry Clinic and practicing veterinarians together, the Clinic invited a few veterinarians in 1967 for an exchange of ideas and experience on current disease problems. In view of the many unanswered questions exchanged, it was decided to meet semi-annually to continue the dialogue among colleagues. These meetings continue to this date, and the spirit follows the original intention of an open exchange among academic and applied poultry veterinarians.

On the occasion of the 50th meeting in 1996, Siegmann (6) recalled the early history of these popular meetings, and Salisch (5) presented a complete bibliography with authors, topics and keywords.

The continuing popularity of these meetings would not have possible without the significant contributions of many invited speakers and the contributions of colleagues during the subsequent discussions. Starting in 1996, Prof. Neumann organized the annual meetings, since 2011 Prof. Sylke Rautenschlein, the present director of the Poultry Clinic, continues the tradition.

Summary

Poultry diseases are recorded as a subject at the “Royal Veterinary School” in Hannover as early as 1834. Since the 1960s, poultry and poultry diseases developed into an own subject at the Veterinary University Hannover. Initially integrated into the “Institute for Animal Hygiene and Poultry Diseases”, the present “Poultry Clinic” was developed.

In this paper, the history of the development is recalled with respect to teaching and research activities. The “Compendium on Poultry Diseases” and the “Discussions among Poultry Experts” are described as two remarkable activities of the Veterinary University in Hannover.

Fachgebiet "Geflügelkrankheiten" an der Stiftung Tierärztliche Hochschule Hannover

(University for Veterinary Medicine Hannover, Germany)
O. Siegmann

1. Vorgeschichte

Die Beschäftigung mit Krankheiten des Federviehs in der damaligen "Königlichen Thierarzneyschule zu Hannover", hervorgegangen aus der 1778 gegründeten "Roßarzneyschule", lässt sich bis in das Jahr 1834 zurückverfolgen. Ab diesem Zeitpunkt waren, wenn auch nur in bescheidenem Umfang, alle Wirtschaftsgeflügelarten sowie Wild- und Ziervögel Gegenstand klinischer Bemühungen oder pathologisch - anatomischer und aetiologischer Untersuchungen.

Die erste, einer Geflügelkrankheit gewidmete Veröffentlichung war "Beobachtungen über die Vogelpest" von Otto Künnemann (3), erschienen 1902 in der DTW. Das wachsende Interesse am Geflügel, seinen Produkten und Krankheiten belegt eine Vielzahl nachfolgender Publikationen aus verschiedenartigen Fachgebieten stammend. Erster Promovend war 1912 Hellmuth Hempel (1) mit seiner Dissertation "Über eine Colibacillose der Hühner und Untersuchungen normaler Hühnerdärme auf das Vorkommen der Bakterien aus der Coli-Typhus-Gruppe". Die erste Lehrveranstaltung wurde im SS 1930 von Prof. Wilhelm Krüger (2) mit "Anatomie des Geflügels und der Versuchssäugetiere" angeboten.

Für die Entwicklung der Tierärztlichen Hochschule (TiHo) war die Jahrhundertwende bedeutungsvoll. 1887 zu einer wissenschaftlichen Einrichtung erhoben, konnten 1899 neuerbaute Institute und Kliniken am damaligen Ostrand der Stadt Hannover bezogen werden. Die Hochschule erlangte 1910 das Promotionsrecht und 1918 eine Habilitationsordnung. Zwischenzeitlich (1913) war das Direktorat durch eine Rektoratsverfassung abgelöst worden. Seit 2002 wird die TiHo von einem hauptamtlichen Präsidenten geleitet und wurde 2003 in die Trägerschaft einer Stiftung überführt.

Dadurch war und ist die Selbstständigkeit gesichert, die es erlaubt, flexibler und rascher auf neue Herausforderungen zu reagieren, als dies einer Fakultät im universitären Verbund möglich ist. So war die TiHo beispielsweise 1963 Ausrichter des 17. Welttierärztekongresses in Hannover, beherbergt seit 1972 das "WHO Collaborating Centre for Research and Training in Veterinary Public Health" und erfreut sich 24 internationaler Partnerschaften und Kooperationen.

Zukunftsweisend konnte 1953 ein umfangreiches Neubaugelände am Bünteweg in Hannover-Kirchrode (Westfalenhof) erworben werden, auf dem längerfristig alle Einrichtungen ihren Platz finden werden. Derzeit verfügt die TiHo über 6 Kliniken, 20 Institute, 3 Fachgebiete, 2 externe Organisationseinheiten, ein Lehr- und Forschungsgut sowie eine Ausbildungsstätte für Vet.med.- technische Assistent(inn)en. Der Lehrkörper umfasst >200 Personen, die Zahl der Studierenden ca. 2000, wobei der männliche Anteil unter 20 Prozent liegt.

2. Institut für Tierhygiene und Geflügelkrankheiten

Wegbereitend für das Fachgebiet der Geflügelkrankheiten war 1949 der weitreichende Senatsbeschluss, die Kliniken nach Tierarten neu zu ordnen und bestehende Einrichtungen aufzuteilen. U. A. waren Institute für Tierhygiene sowie Geflügelkrankheiten vorgesehen. Nachdem sich die Besetzung des Hygienelehrstuhls zerschlagen hatte, beschloss der Senat 1955 ein Institut für "Tierhygiene und Geflügelkrankheiten" einzurichten. Auf den gleichnamigen Lehrstuhl wurde 1960 Frau Prof. Irmgard Gylstorff berufen. Es war eine Doppelpremiere: Die erste o. Professorin der Veterinärmedizin, betraut mit dem ersten Lehrstuhl für Geflügelkrankheiten im mitteleuropäischen Raum.

Trotz provisorischer räumlicher Enge im Chemischen Institut, anfangs mit bescheidener personeller und finanzieller Ausstattung, entwickelte sich unter ihrer Leitung reges wissenschaftliches Leben. Erschwerend war auch das Fehlen geeigneter Versuchstierställe vor Ort auf dem alten Hochschulgelände am Bischofsholer Damm. Zur Sicherstellung der studentischen Ausbildung wurden eine umfangreiche diagnostische Tätigkeit und die ambulatorische Betreuung von Wirtschaftsgeflügelbeständen aufgenommen sowie ein Behandlungszimmer für Zier- und Wildvögel eingerichtet.

Die Wissensvermittlung musste in Lehrveranstaltungen der Hygiene und Inneren Medizin integriert werden. Frühzeitig wurden auch Fortbildungsveranstaltungen in Zusammenarbeit mit anderen Hochschuleinrichtungen organisiert.

Mit großem Fachwissen und unermüdlicher Tatkraft eroberte Frau Gylstorff in wenigen Jahren den Geflügelkrankheiten einen festen Platz innerhalb und außerhalb der Hochschule. Ihr überaus erfolgreiches Wirken hat nicht zuletzt 1965 zu ihrer Berufung auf den neu errichteten Geflügellehrstuhl an der Vet.Med. Fakultät in München geführt.

3. Klinik für Geflügel

In den 60er Jahren befand sich die einheimische Geflügelwirtschaft in einem radikalen Umbruch mit einer Fülle neuer Herausforderungen für die Veterinärmedizin. Dies bewog den Senat, anlässlich der Nachfolgeregelung die Tierhygiene auszugliedern und den Geflügelkrankheiten allein ein Institut zu widmen. Mit der Leitung wurde 1966 Prof. Otfried Siegmann betraut.

Dank Berufungszusagen und begünstigt durch Empfehlungen des Deutschen Wissenschaftsrates entstand schrittweise die jetzige "Klinik für Geflügel". Schon 1968 konnte auf dem Neubaugebiet Westfalenhof ein Isolierhaus in 1. Ausbaustufe, 2 Jahre später in endgültiger Form, zur Durchführung von Tierversuchen und der Haltung von SPF-Tieren in Betrieb genommen werden. Der Umzug vom Bischofsholer Damm in das unmittelbar benachbarte, neu erbaute 1. Dreierinstitut erfolgte 1974. Im dortigen Erd- und 1. Obergeschoss bestehen seitdem sehr gute Arbeitsbedingungen. Bei der Raumplanung konnte als neues Konzept die Gliederung in Arbeitsgruppen realisiert werden. Der gemeinsamen Aufgabe verpflichtet, erlaubt und fördert diese Organisationsform die unumgänglich gewordene, insbesondere methodische Spezialisierung, die Forschung, Lehre und Dienstleistung gleichermaßen dienlich ist (Abb.1).

Abbildung 1: Arbeitsgruppen im Institut für Geflügelkrankheiten

Ambulatorische Klinik		**Allgemeine Labordiagnostik**		**Klinik für Zier- und Wildvögel**
Bakteriologie		**Parasitologie**		**Virologie**

Schweren Herzens war zuvor der Entschluss zustande gekommen, die florierende Poliklinik für Zier- und Wildvögel am alten Standort zu belassen. Sie sollte weiterhin von der Klientel mit öffentlichen Verkehrsmitteln erreichbar bleiben. Durch Umzug in das alte Apothekengebäude und nachfolgend in freigewordene Räume der Pathologie, konnte sich auch diese Arbeitsgruppe wesentlich verbessern und hat sich einen vorzüglichen Ruf erworben. Seit 2009 ist sie in der neuformierten "Klinik für Heimtiere, Reptilien, Zier- und Wildvögel" im neuen Klinikum am Bünteweg beheimatet. Damit wurde leider das Konzept der Tierartenkliniken aufgeweicht.

Auch die Geräteausstattung gelang zufriedenstellend und konnte später von Prof. Ulrich Neumann, der 1992 die Klinikleitung antrat, nachhaltig verbessert und erweitert werden. Erhebliche Investitionen erfolgten, um mit dem zwischenzeitlichen Kenntniszuwachs und methodischen Entwicklungen insgesamt, insbesondere im Bereich der Molekularbiologie und Immunologie, Schritt zu halten.

Ende der 70er Jahre umfasste der Mitarbeiterstab 28 Personen, davon 10 mit akademischer Qualifikation. Daneben bereicherten immer Doktoranden, Stipendiaten und Gastwissenschaftler in wechselnder Zahl unterschiedlichster Nationalitäten das Leben und die wissenschaftliche Arbeit der Klinik. Einzelheiten wer, wann, in welcher Aufgaben- oder Dienststellung tätig war, ist in den Personen- und Vorlesungsverzeichnissen der Hochschule (4) nachlesbar. Leider ist diese umfassende Informationsquelle letztmals zum WS 2008/09 erschienen. Seitdem muss man sich interessierende

Daten im Internet zusammensuchen. Das gilt auch für detaillierte Angaben über das Lehrangebot und dessen Veränderungen im Verlauf der Jahrzehnte. Die Geflügelkrankheiten sind erst 1967 ein obligatorisches Fach der tierärztlichen Ausbildungs- und Prüfungsordnung geworden.

Zur Vertiefung des Studiums, in engem Kontakt mit der Forschung, bietet die TiHo seit 1969 ein 2-jähriges Aufbaustudium an und ab 1998, wiederum als Vorreiter in Deutschland, ein PhD-Studium nach angloamerikanischem Vorbild.

Über die Forschungsaktivitäten der TiHo-Hannover unterrichtet jährlich ein Verzeichnis der wiss. Veröffentlichungen (8). Darin finden sich ab 1960 mehr als 800 Titel und über 150 Dissertationen sowie 6 Habil-Arbeiten, die aus der Klinik für Geflügel hervorgegangen sind oftmals in enger Zusammenarbeit mit anderen Hochschuleinrichtungen und praktizierenden Kolleginnen und Kollegen. Die Thematik spiegelt das Spektrum der Fragestellungen wider, die in den vergangenen Jahrzehnten bearbeitet wurden.

4. Kompendium der Geflügelkrankheiten

Beim ständigen Wissenszuwachs über Aetiologie, Diagnose, Prophylaxe und Therapie ist eine umfassende Vermittlung in Lehrveranstaltungen nicht möglich. Den Studierenden bleibt auch kaum Zeit, anhand der Spezialliteratur den aktuellen Stand zu verfolgen. Dies veranlasste Siegmann 1971, ein "Kompendium der Geflügelkrankheiten" als Ergänzung zur Vorlesung und Aneignung unumgänglicher Grundkenntnisse herauszugeben, das 2012 die 7. Auflage erlebt hat (7).

Das Kompendium hat durch Beteiligung der langjährig bewährten Mitarbeiter, K.-H. Hinz, E.-F. Kaleta und H. Lüders (3.Aufl.) und nachfolgend von Prof. G. Monreal, Berlin, und Prof. J. Kösters, München, zunehmend Anklang gefunden. Ab der 6. Aufl. ist Prof. U. Neumann Mitherausgeber. Das Autorenkollektiv umfasst seitdem 35 Kolleginnen und Kollegen aus allen deutschsprachigen vet.med. Bildungsstätten, aus Forschungseinrichtungen, Praxis und Verwaltung. Die ursprüngliche Studierhilfe ist im Verlauf der Jahre ein führendes Fachbuch über Geflügelkrankheiten geworden. Dafür sei an dieser Stelle allen Beteiligten für ihre selbstlose, ideelle Mitarbeit herzlicher Dank gesagt.

5. Fachgespräch über Geflügelkrankheiten

Im Bemühen um einen engen Schulterschluss mit der Praxis lud die Geflügelklinik 1967 einige Kollegen zu einem Gedanken- und Erfahrungsaustausch ein. Angesichts der Fülle offener Fragen kam man überein, sich zukünftig möglichst halbjährig zu einem "Fachgespräch" (FG) zu treffen. Mit dieser Benennung sollten partnerschaftlicher Dialog und Zusammenarbeit postuliert werden. Diese Leitlinie hat bis zum heutigen Tag ihre Gültigkeit behalten.

Anlässlich der 50. Veranstaltung 1996 berichtete Siegmann (6) über Anfänge und Zwischenstationen der FG, und PD H. Salisch (5) legte eine umfassende Bibliographie nebst einem Stichwortverzeichnis vor. Daraus sind die bis dahin 260 abgehandelten Themen sowie die Namen der Referenten ersichtlich. Einen Überblick über die zeitliche Entwicklung von Schwerpunkten gibt Tabelle 1.

Ohne die tätige Mitwirkung der Referenten und die lebhaften Diskussionsbeiträge zahlloser Kolleginnen und Kollegen ist die Erfolgsgeschichte der FG undenkbar. Die Fortführung übernahm 1996 U. Neumann und seit 2011 liegen Vorbereitung und Durchführung der FG in den Händen von Prof. Sylke Rautenschlein, der jetzigen Direktorin der Klinik für Geflügel.

Das 85. Fachgespräch findet im November 2013 statt.

Tab. 1: Dominante Themen der Fachgespräche

Thematik	1967-1980	1981-1995
Aetiologie/ Diagnostik	Marek/Leukose IB-Mutanten EDS 76 Mykoplasmen/Coryza - Stichprobenuntersuchungen	Salmonellose Campylobacter Pasteurellosen Paramyxoviren - Elisa/Molekularbiologie
Prophylaxe	Vaccine: - Marek - Gumboro - ILT - EDS 76 Antikokzidia	Vaccine: - Inf. Anämie - Mykoplasmosen - Coriza - Salmonellosen - Pasteurellosen
Therapie	Herdenbehandlung - Trinkwasser - Futter	Rückstandsproblematik - Haltungsart - Wartezeiten
Haltung/ Tierschutz	Stallklima Fütterung Schmerzhafte Eingriffe	Käfig/Kleingruppe Boden/Voliere Herdeneuthanasie
Gesetze	Meldepflicht Novellierung - Arzneimittelgesetz AMG - Futtermittelgesetz FMG	Futterzusatzstoffe Tierarzneirecht EU

Zusammenfassung

Schon Mitte des 19. Jahrhunderts war das Geflügel Gegenstand tierärztlicher Bemühungen an der damaligen „Königlichen Thierarzneyschule zu Hannover“. Erst 1960 wurden das Geflügel und seine Krankheiten zum eigenständigen Fachgebiet an der TiHo-Hannover. Zunächst im Institut für „Tierhygiene und Geflügelkrankheiten“ integriert, entstand die heutige „Klinik für Geflügel“.

Der schrittweise Aufbau in räumlicher und personeller Hinsicht sowie Lehre und wissenschaftliche Aktivitäten werden umrissen. Abschließend wird kurz die Entstehung des Fachbuches „Kompendium der Geflügelkrankheiten“ geschildert und auf die „Fachgespräche über Geflügelkrankheiten“ in Hannover eingegangen.

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Selection for improved leg health in purebred broiler lines

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INTRODUCTION

Leg health has been an important component of broiler welfare and of the economy of broiler production for many decades and includes a wide range of leg disorders leading to locomotion problems (e.g. Thorp, 1994; SCAHAW, 2000; Bradshaw *et al.*, 2002). This article will focus on five leg health traits recorded within the Aviagen Ltd (Newbridge, UK) breeding programme, namely (1) long bones deformities (LD), including valgus/varus and bowed legs, (2) crooked toes (CT), (3) tibial dyschondroplasia (TD), (4) hock burn (HB) and (5) foot pad dermatitis (FPD).

Long bones deformities are among the most common forms of leg weakness; tibial dyschondroplasia was the most frequent lesion in bones of broiler legs (SCAHAW, 2000). FPD and HB are two forms of contact dermatitis, visible as ulcerations of the skin of the foot or hock, with discoloration, inflammation and necrosis (Martland, 1984; Greene *et al.*, 1985; Mayne, 2005). Leg disorders are associated with a range of welfare issues, including pain, reduced activity, and decreased feed intake due to pain (Martland, 1984 and 1985; Julian, 1998; Kestin *et al.*, 1999). In Europe levels of contact dermatitis at post-mortem inspections are used as an indicator of poor welfare conditions (Council of the EU, 2007).

Trial studies and surveys have shown there are substantial differences among broiler strains in the prevalence of leg disorders (e.g. Kestin *et al.*, 1999; Yalçin *et al.*, 2000; Sanotra *et al.*, 2003; DEFRA, 2010). This reflects in part the large differences that exist in management and environment factors – such as litter quality, age at slaughter or stocking density (Ekstrand *et al.*, 1997; Sanotra *et al.*, 2003) - but also the differences in genotypes (Kestin *et al.*, 1999; Sanotra *et al.*, 2003). Mercer and Hill (1984) estimated heritabilities of 0.29 to 0.62 for a range of leg health traits (crooked toes, splay leg, bowed leg) in three purebred commercial broiler lines, with low but unfavourable genetic correlations with body weight (BWT) at 0.00 to 0.27. Le Bihan-Duval *et al.* (1996; 1997) found valgus and varus deformity heritabilities in two commercial broiler strains of 0.15 to 0.39, with genetic correlations with BWT at -0.06 to 0.12. Chen *et al.* (2011) estimated heritabilities of 0.11 and 0.09 for leg angle in a purebred broiler sire line and dam line, respectively. Kjaer *et al.* (2006) were the first to report estimates of heritability for HB (0.08) and FPD (0.31) and their genetic correlation with BWT (0.44 and -0.08, respectively). More recently, Ask (2010) estimated heritabilities for HB and FPD in two purebred commercial broiler male lines at 0.10 (HB, in both lines) and 0.21 and 0.08 (FPD). The genetic correlations of BWT with HB (0.14 and 0.16) and FPD (-0.51 and 0.08) did not differ significantly from those found by Kjaer *et al.* (2006).

While studies found differences in the prevalence and heritabilities for FPD between strains within an environment (Kestin *et al.*, 1999; Kjaer *et al.*, 2006; Ask, 2010), none compared broilers from the same genetic background reared in different environments. Long term selection on production traits in one environment will lead to increased productivity under those circumstances, but in the presence of genotype by environment interaction (GxE) this may cause problems when animals are placed in a different environment (Van der Waaij, 2004). To evaluate of the effect of GxE on FPD, this trait is recorded in two contrasting environments.

In this article we aim to (1) document the changes of leg health in purebred commercial broiler lines (contributing significantly to the Ross 308 and the Ross 708 crossbred) in the Aviagen Ltd breeding programme following 25 years of selection; (2) estimate heritabilities for a range of leg health traits under selection in an optimal environment (LD, CT, TD, HB, and FPD) and a sub-optimal environment (FPD); (3) estimate genetic correlations of these traits with BWT; and (4) investigate the effectiveness of combined selection for FPD and BWT, and the potential to increase the genetic merit for a trait across different environments.

MATERIAL AND METHODS

Birds

The data for this study originate from the ongoing leg health recordings within the Aviagen Ltd breeding programme. Birds were individually weighed and visually assessed for leg health by a trained team at 5 wk of age (6 wk between 1987 and 1998) to maintain commercial relevance. The team of scorers was regularly assessed for consistency using correlations between and within selectors. Scorers were regularly assessed for satisfactory repeatability scores and not allowed to assess selection candidates until they completed a training period of at least two years. One scorer remained in the team from 1965 till 2012. For estimation of genetic parameters, records for 910,737 birds across four lines were used, collected between October 2007 and September 2010, with an additional generation of pedigree.

Housing

The birds were housed in two contrasting environments: (1) a high bio-secure environment where breeding programme selection candidates are recorded and selected (pedigree (P) environment) and (2) a non bio-secure environment where full-sibs and half-sibs of selection candidates are tested under broader commercial conditions (sib-test (S) environment). All birds had ad libitum access to water and a high quality pelleted diet throughout the growing period. In the P environment, the diet consisted of a broiler starter (up to 10 days of age; 220-250g CP/kg; 12.6MJ ME/kg), followed by a grower (up to 25 days of age; 210-230g CP/kg; 13.3MJ ME/kg) and a finisher (25 days onwards; 190-210g CP/kg; 13.5MJ ME/kg). In the S environment, the starter diet (up to 10 days of age; 195g CP/kg; 12.0MJ ME/kg) was followed by a grower (10 days onwards; 170g CP/kg; 12.7MJ ME/kg).

The stocking density was 27 to 33 kg/m^2 (P) and 22 to 27 kg/m^2 (S), in accordance with the maximum stocking density of 33 kg/m^2 as laid down in the EU Council Directive 2007/43/EC (Council of the EU, 2007). Wood shavings were supplied as litter, and topped up as required. From April 2010 onwards, the amount per top up was reduced to allow the further expression of HB and FPD. In the P environment, the litter was replaced completely at the end of each cycle. In the S environment, half of the litter was retained at the end of each cycle, mechanically conditioned and subsequently topped up with fresh wood shavings.

Traits

All traits were assessed at five weeks of age except line D in the P environment at six weeks from October 2008. LD was defined as a bird displaying either a valgus or a varus deformity of the tarsometatarsi and, to a lesser extent, the tibiotarsi, or a bending of the tarsometatarsi, sometimes continued in the middle forward digit. CT was defined as curling of one or more of the toes due to a deviation of the phalanges, giving the foot a crab-like appearance. Both traits were binomially scored as (0) unaffected or (100) affected.

TD was assessed using a low-intensity x-ray imaging scope (lixiscope) and scored on a 3-point scale, depending on the extent to which abnormal cartilage developed in the tibia: no lesions (score 0), moderate lesions or severe lesions. For subsequent analyses, moderate and severe lesions were combined into one category (score 100). From 1990 till 2006 a first generation lixiscope device was used, and a newer and more accurate version since 2007. TD was measured only in males identified as selection candidates, based on a selection step that combined breeding values for performance traits and a thorough physical assessment including no clinical prevalence of LD and CT. As a consequence only subclinical TD was scored. In line A, from 2010 onwards TD was measured on all males. LD, CT and TD, were considered to be major disorders, and any bird showing either one of them was discarded for breeding and culled using a ‘zero tolerance’ policy.

HB was scored on a four-point scale: 0% - no lesions (score 0); up to 25% of the surface affected - slight lesions; between 25 and 50% - moderate lesions; or more than 50% - severe lesions (score 100). For subsequent analyses, slight and moderate lesions were combined into one category (score 50). FPD was scored and analyzed on a three-point scale: 0% - no lesions (score 0); up to 50% of the surface affected - mild lesions (score 50); or more than 50% - severe lesions (score 100). For all traits, a stringent approach was used, whereby both legs were evaluated and the higher scoring leg determined the final score.

Long-term phenotypic trends

Historical data for this study were available from January 1986 onwards for three purebred commercial broiler lines (line A ~1.0 million birds, line B ~1.5 million birds and line C ~2.3 million birds), thus comprising more than 25 years of selection for leg health. The mean prevalence of leg defects per sex per week was available from January 1986 for LD and CT, from December 1990 for TD and from July 1990 for HB. The trends are based on the weekly prevalence, calculated as the average of the sexes and are given as raw phenotypic trends; due to the categorical nature of the traits, no corrections for environmental changes were made. Minor changes occurred in environmental factors such as feed, lighting programme and litter management. All broilers were managed according to the specifications in the contemporary Aviagen Broiler Manual (1982, 1995, 1996, 1999, 2002, 2005 and 2009) and the corresponding nutritional recommendations.

Statistical Analyses

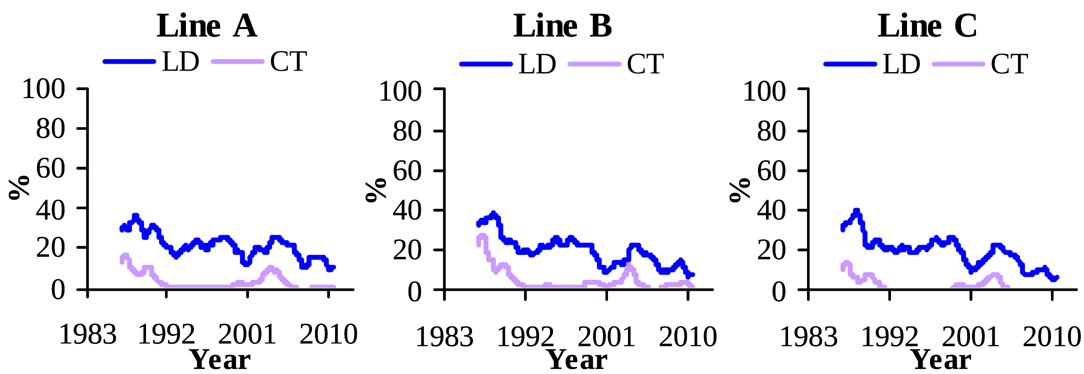
Two multivariate animal models were used to estimate genetic parameters per line. Model (1) included BWT and the four leg health traits LD, CT, TD, and HB (Lines A to C). Model (2) included BWT and FPD as separate traits depending on the environment: BWT-P, BWT-S, FPD-P and FPD-S (Lines A to D). The models included a fixed effect accounting for the interaction between the hatchweek, pen, contributing mating group and sex of the individual, as well as the random effects of the permanent environmental effect of the dam and the additive genetic effect of the animal. All variance component analyses were performed by REML using VCE (Groeneveld et al., 2008). The inclusion of BWT in the multivariate analysis ensured that estimates for leg health traits were not biased due to weight associated effects and selection. The estimates from model (2) were subsequently used to estimate breeding values and predict long-term genetic trends using PEST (Groeneveld, 2006).

RESULTS AND DISCUSSION

Long-term phenotypic trend

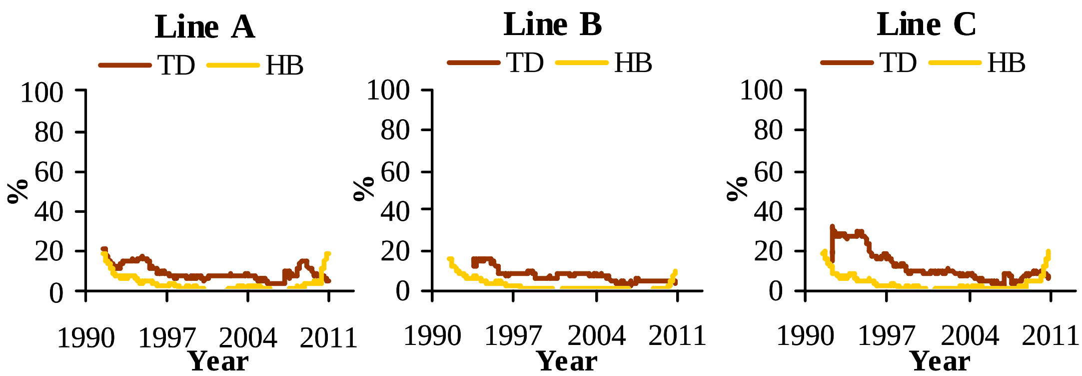
From 1986 till 1996, LD decreased by -1.4 to -1.6%/yr, while CT decreased by -1.2 to -2.3%/yr (Figure 1). CT stabilized at low levels, while LD has continued to decrease (-0.7 to -1.2%/yr). The phenotypic trends for LD and CT show a peak around 2003, coinciding with two changes in management: a reduction in digestible phosphorus levels in the feed and in skeletal defects recording procedure. Subsequently they fell, although recently the prevalence of CT increased slightly until October 2009, especially in line B. This coincides with a change in lighting programme to a 6 hours dark period, meeting forthcoming EC recommendations (Council of the EU, 2007), though the reasons for this effect are unclear.

Figure 1 Prevalence of long bone deformity (LD) and crooked toes (CT) between October 1985 and September 2010 (1 yr moving average).



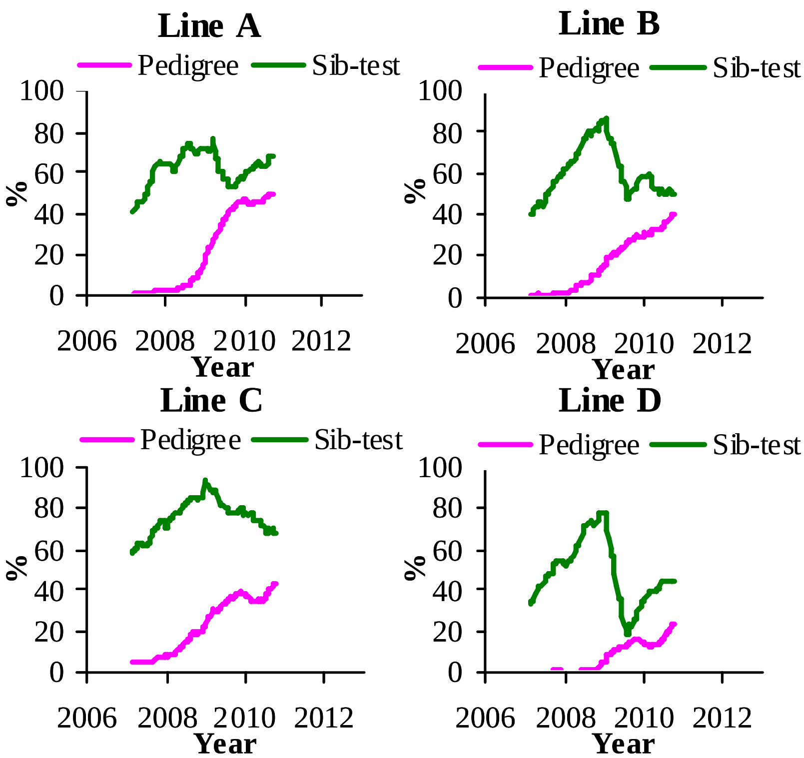
Between 1990 and 2006, TD steadily decreased by -0.6 to -1.8%/yr (Figure 2). Its prevalence increased post 2007 linked with the change to a more accurate device, but declined rapidly from 2008 by -1.0 to -5.2%/yr. HB showed a large decrease (1.3 to 1.5%/yr) in the first 10 years after initiating recording of this trait, after which its prevalence stabilized at very low levels (Figure 2). Reduction of the selection age from 6 to 5 wk in 1998 coincided with a minor decrease of LD prevalence, but did not affect CT, TD and HB, which were already at very low levels.

Figure 2 Prevalence of tibial dyschondroplasia (TD) between December 1990 and September 2010 (1 yr moving average) and prevalence of hock burn (HB) between July 1990 and September 2010 (1 yr moving average).



Recording of FPD started in 2006 (Figure 3). In the P environment, the prevalence increased between 2006 and 2010 by 9.4 to 17.3%/yr, while no clear phenotypic trend was visible in the S environment. The recent increase in FPD and HB in the P environment coincides with a change in litter management policy from April 2010, whereby litter was topped up with fewer shavings on a routine basis, leading to a reduction in litter quality through an increase in moisture, thereby increasing the prevalence and the variation that can be used in selection.

Figure 3 Prevalence of foot pad dermatitis in the pedigree and sib-test environment between January 2006 and September 2010 (1 yr moving average).



Contemporary prevalence of leg disorders

The number of observations, BWT means and leg disorders prevalence in each line from October 2007 to September 2010 are given in Table 1. Consequent on their different origins and emphases given to weight and growth traits, the average BWT ranged from 2.4 kg (line A) to 1.7 kg (line D). The ratio of BWT-S to BWT-P was consistent across lines at on average three quarters, though lines B and C showed a re-ranking with a higher BWT in line C in the S environment.

Table 1 Mean values for body weight (BWT) and prevalences of long bone deformity (LD), crooked toes (CT), tibial dyschondroplasia (TD), hock burn (HB) and foot pad dermatitis (FPD) in the pedigree (P) and sib-test (S) environment for October 2007 till September 2010.

	P							S		
		BWT	LD	CT	TD[1]	HB	FPD		BWT	FPD[2]
Line	n	Mean (SD)	P_{tot}	P_{tot}	P_{tot} (P_{sev})	P_{tot} (P_{sev})	P_{tot} (P_{sev})	n	Mean (SD)	P_{tot} (P_{sev})
A	132,813	2,373 (267)	0.129	0.006	0.078 (0.011)	0.098 (0.001)	0.371 (0.092)	15,339	1,804 (369)	0.637 (0.542)
B	217,943	2,040 (234)	0.109	0.026	0.046 (0.008)	0.040 (0.000)	0.261 (0.066)	40,371	1,511 (302)	0.654 (0.569)
C	248,096	1,951 (234)	0.086	0.006	0.080 (0.012)	0.122 (0.004)	0.331 (0.090)	45,942	1,576 (300)	0.792 (0.703)
D[3]	181,783	1,740 (209)	-	-	-	-	0.141 (0.032)	28,450	1,416 (289)	0.453 (0.350)

n = number of records, mean and SD in grams, P_{tot} = total prevalence, P_{sev} = prevalence of severe lesions for TD, HB and FPD.
1 Only recorded on selected males: 28,566 in line A, 17,999 in line B and 19,361 in line C
2 In the pedigree environment all birds were scored for FPD.
In the sib-test environment the proportion of birds scored for FPD exceeded 98%
3 measurements for BWT in the pedigree environment from October 2008 onwards corrected to 5wk weight

Table 2 Predicted yearly genetic trend for BWT and FPD in the P and the S environment for August 2006 till September 2010. For key to traits, see Table 1.

	P		S	
Line	BWT	FPD	BWT	FPD
A	+ 3.2%	- 4.1%	+ 2.6%	- 1.3%
B	+ 2.6%	- 7.5%	+ 3.0%	- 1.6%
C	+ 2.6%	- 3.4%	+ 3.8%	- 0.5%
D	+ 3.2%	- 7.1%	+ 2.9%	- 6.6%

LD showed the highest prevalence of the leg health traits (8.6 to 12.9%). This is lower than that of long bone deformities in other studies e.g. 44 to 73% for valgus and varus (Le Bihan-Duval et al., 1996) and 16 to 19% for unacceptable leg angles (Chen *et al.*, 2011). In contrast to LD, CT showed a much lower prevalence (0.6 to 2.6%), which is lower than in 1984 (3 to 5% - Mercer and Hill, 1984). The TD prevalence ranged from 4.6 to 8.0%, which is lower than reported by Sanotra *et al.* (2003) in a range of commercial crosses and environments (45 to 57%). However, TD was generally only recorded on pre-selected males with no clinical leg defects; the TD prevalence in the un-selected birds is likely to be higher.

The prevalences of HB (4.0 to 12.2%) and FPD (14.1 to 79.2%) are within the wide range found in standard rearing systems in Europe for HB (1 to 89% - Kjaer *et al.*, 2006; Haslam *et al.*, 2007; Ask,

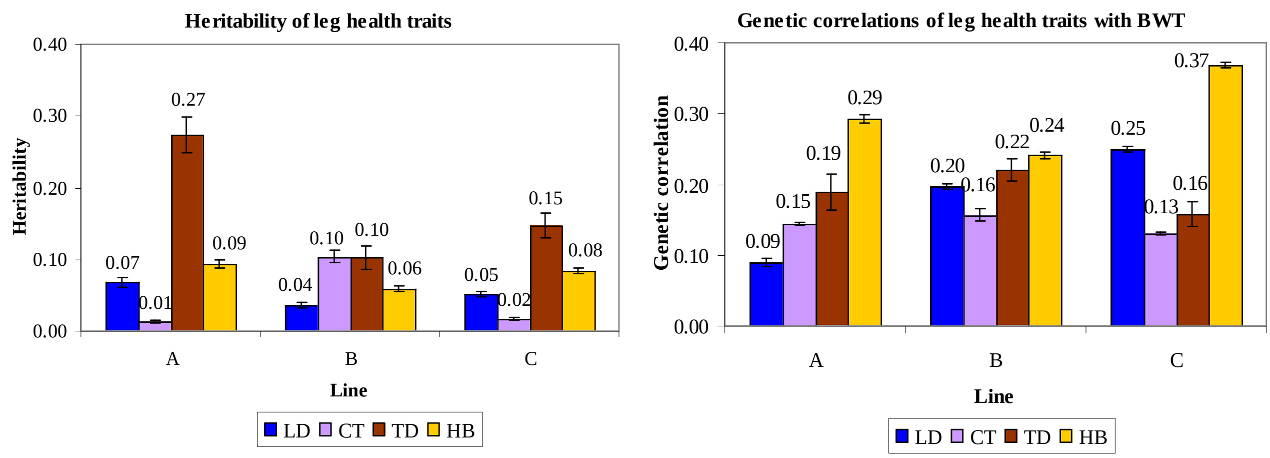
2010) and FPD (11 to 93% - Sanotra *et al.*, 2003; Kjaer *et al.*, 2006; Pagazaurtundua and Warriss, 2006; Haslam *et al.*, 2007; Ask, 2010). The large differences in HB and FPD prevalence between these studies may in part be due to the scoring systems – the present study used a three-point scale, compared to up to nine different categories in other studies (e.g. Kjaer *et al.*, 2006; Pagazaurtundua and Warriss, 2006; Haslam *et al.*, 2007; Ask, 2010). While more categories would allow increased discrimination, those used in this study have the advantage that they are easy to distinguish and score repeatably.

The FPD prevalence differed markedly between the two environments. Dawkins *et al.* (2004) concluded that not only stocking density but also a wide range of housing conditions, including temperature, humidity and litter moisture, play a major role in leg health and overall welfare of broilers. The P and S environment differed substantially in diet, litter management and temperature, which together are likely the main factors that contributed to the differences in prevalence.

Heritability of leg health

BWT heritability estimates in model (1) were 0.33 in line C, 0.36 in line A and 0.40 in line B. LD (0.04 to 0.07) and HB (0.06 to 0.09) heritability estimates varied little between the lines (Figure 4). The LD estimates are comparable to those of Chen et al. (2011), but slightly lower than those of Le Bihan-Duval *et al.* (1996; 1997). On the underlying scale, these estimates (0.10 to 0.17) are lower than those for splay and bow estimated by Mercer and Hill (1984). HB heritability estimates are in line with those found by Kjaer *et al.* (2006) and Ask (2010).

Figure 4 Comparison of (a) the estimated heritabilities and (b) the genetic correlations with BWT for LD (blue bar), CT (lavender bar), TD (brown bar) and HB (gold bar).

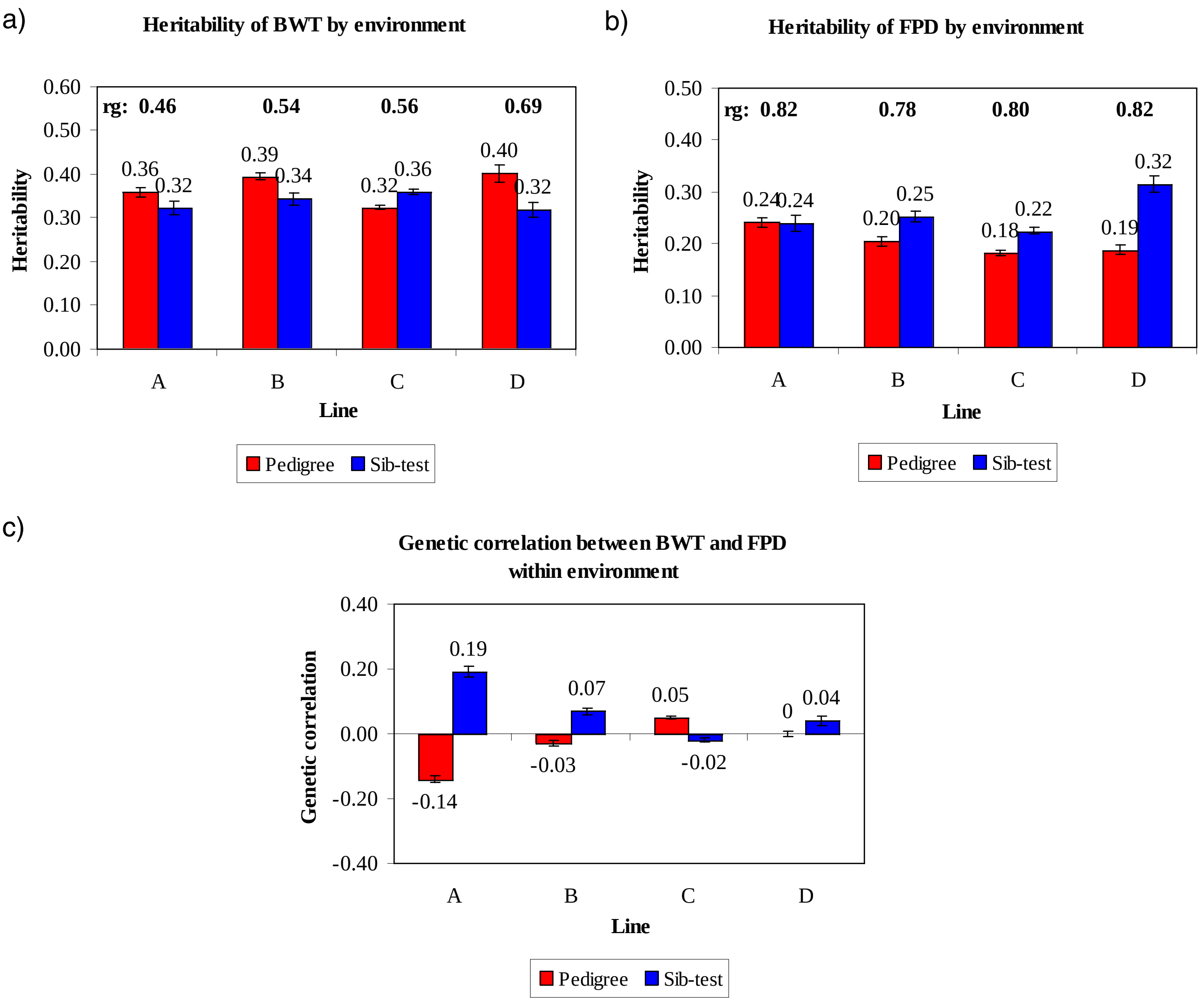


A minor difference between lines was seen for CT, where heritability estimates for lines A (0.01) and C (0.02) were lower than for line B (0.10). On the underlying scale they showed a larger range (0.29 to 0.72) than those estimated by Mercer and Hill (1984). A larger difference between lines was found for TD, with heritability estimates of 0.10 and 0.15 for lines B and C, respectively, and 0.27 for line A.

BWT heritability estimates in model (2) ranged from 0.32 to 0.40 in the P environment and 0.32 to 0.36 in the S environment (Figure 5a). The FPD heritabilities were low to moderate (0.18 to 0.24). No difference in heritability between the two environments was found for line A, but the other lines showed increased heritabilities in the S environment, (0.22 to 0.32) (Figure 5b). These estimates are within the range of the heritabilities found in other studies (Kjaer *et al.*, 2006; Ask, 2010).

Ask (2010) attributed the difference in FPD heritability between lines in part to the prevalence, but we found no clear relation between prevalence and heritability estimate. Heritabilities on the observed scale depend on the choice of categories and their frequencies, and are lower than on a continuous underlying scale (e.g. Dempster and Lerner, 1950; Gianola, 1982). While transformation of the estimated heritabilities to the underlying continuous scale resulted in higher estimates, from a practical point of view, genetic parameters and breeding value estimates on the observed scale are preferred. Overall, despite minor differences the heritabilities for all traits showed a remarkable concordance across the lines.

Figure 5 Comparison of the estimated heritabilities for (a) BWT and (b) FPD and the genetic correlations between BWT and FPD within environment (c) in the pedigree (red bar) or the sib-test (blue bar) environment.



Genetic correlations between BWT and leg health

The genetic correlations between the leg health traits and BWT in model (1) were all unfavourable but generally low to moderate (Fig. 4b), in line with estimates of Mercer and Hill (1984). All lines showed similar genetic correlations between CT and BWT (0.14 to 0.16) and TD and BWT (0.16 to 0.22). Line A showed a much lower genetic correlation (0.09) between LD and BWT than lines B (0.20) and C (0.25). Low estimates between BWT and valgus or varus deformities were also obtained by Le Bihan-Duval *et al.* (1997), but these increased slightly when the weights of severely affected and probably thereby lighter birds were excluded. A continuous screening approach in our breeding programme ensures that severely affected birds are detected and culled for welfare reasons well before their weight reduces drastically, but leg health may have influenced the weight of the moderately affected birds. Mercer and Hill observed higher genetic than phenotypic correlations between BWT and skeletal health traits, likely in part due to a negative environmental correlation between the traits, with affected birds being less vigorous (Mercer and Hill, 1984). A similar contrast between the genetic and phenotypic correlations was found in the present study, with negative estimates for the correlations between the dam permanent environmental effects and the residual effects of BWT with LD, CT or TD.

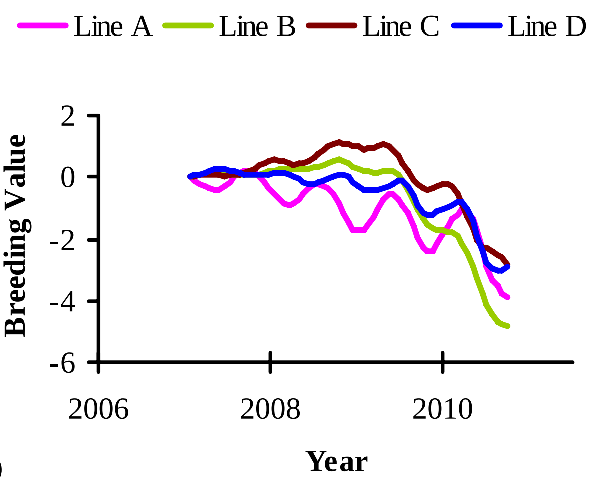
Previous estimates of the genetic and phenotypic correlations between BWT and HB were unfavourable, though few differed significantly from zero (Sørensen *et al.*, 2000; Kjaer *et al.*, 2006; Ask, 2010). The present study confirms this, with moderately positive genetic correlations between BWT and HB. Kjaer *et al.* (2006) hypothesized that a positive correlation between these two traits may be due to a tendency for heavier birds to sit more on their hocks, whereas lighter birds stand more. Genetic correlations between BWT and FPD (Fig. 5c) were either favourable or, if unfavourable, small, as was found by Ask (2010) and Kjaer *et al.* (2006).

Mercer and Hill (1984) predicted that selection programmes for BWT would at best maintain the current levels of prevalence. Nevertheless, despite relatively low heritabilities for leg health traits and unfavourable correlations with BWT, a balanced approach has led to a significant improvement in both BWT (34 to 39 g/yr between 1985 and 2010) and leg health in these lines. The low to moderate genetic correlations of BWT with leg health traits indicate that, from a genetic stand point, there is no evidence that selection for BWT has led and would lead to appreciable decreases in leg health. Moreover, balanced selection including all traits in a selection index is an effective way of achieving continuous improvement in all traits and our results show that the suggestion by Dawkins and Layton (2012), regarding the potential for selecting for welfare and production traits simultaneously despite antagonistic correlations, is already routine practice in a commercial breeding programme.

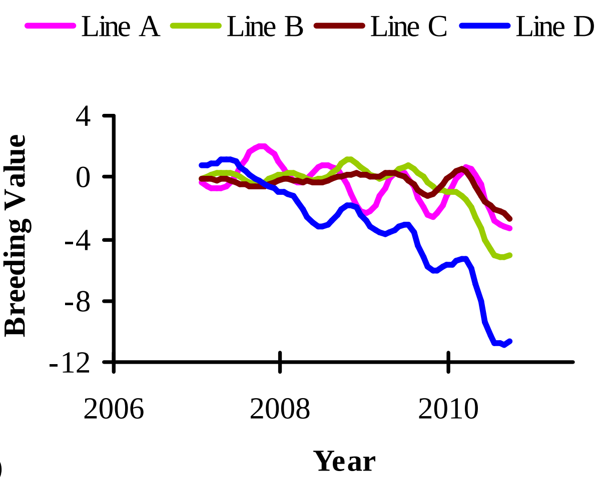
Effectiveness of selection for FPD across environments

Following the start of recording of FPD in 2006, active selection against this trait commenced in 2008; figure 6 shows the predicted genetic trend. It should be noted that BWT and FPD, the only traits used in this prediction, are part of a much larger selection index in the Aviagen Ltd breeding programme, which includes for example growth, lifetime performance, reproduction, liveability and health. There is substantial GxE for BWT, as the genetic correlation between BWT-P and BWT-S is much less than 1 (Figure 5a). In contrast to BWT, the high genetic correlations between FPD-P and FPD-S (Figure 5b) indicate that the effects of a GxE interaction are less pronounced for FPD. The genetic trend predicted that genetic selection for FPD improved the average FPD score steadily at 3.4 to -7.5%/yr (P) and -0.5 to 6.6%/yr (S), while at the same time maintaining progress in BWT. The genetic progress in BWT at 2.6 to 3.8%/yr is in line with the progress in meat production that has been reported in earlier publications, e.g. 2.4 % for BWT (McKay *et al.*, 2000; Hill, 2010) and 2 to 3% for the overall efficiency of meat production (McKay, 2009).

Figure 6 **Genetic predictions for FPD in (a) the pedigree and (b) the sib-test environment. The data are presented as the six months moving average. Note the difference in scale of the y axis between the two traits. Breeding values for FPD were predicted on a scale of 0 to 100.**



a)



b)

Historically, the FPD prevalence in the pedigree lines has been very low, but for effective selection at the breeding programme level it needs to be expressed sufficiently in selection candidates through a higher prevalence and variation. For this reason, both environments have been adjusted to achieve a higher level of FPD expression, resulting in an obvious contrast between the genetic prediction and the actual phenotypic trend.

It is not logistically feasible to record relatives of selection candidates directly in commercial conditions, but the use of farms replicating a range of commercial like-conditions to rear full- and half sibs of selection candidates is an appealing strategy to address the effects of GxE interactions. For FPD, a reduction of the disposition to develop FPD under commercial conditions can be achieved through direct selection in the P environment and through a correlated response from recording in the S environment. The predicted genetic trend for FPD, a result of continuous selection of candidates with an average prevalence below the average population prevalence, shows that selection against FPD can be expected to be successful, while the phenotypic trend has remained stable or increased. The achievement of a trend that reduces the genetic propensity of commercial broilers in developing FPD in a wide range of environments is what will ultimately benefit the industry and the welfare of the animals as a whole.

CONCLUSION

We have shown that both broiler leg health and weight have been improved in a selection programme. Considerable decreases in the prevalence of leg disorders have been achieved by a strong focus on accurately scoring selection candidates and a stringent culling policy of discarding any selection candidate with clinical leg defects. In addition, predicted breeding values for candidates with non-clinical leg defects allowed the identification of families that were prone to develop leg issues. Although the heritabilities of leg health traits were low to moderate and their genetic correlations with BWT often somewhat unfavourable, breeding strategies for simultaneous selection for live performance and leg health have been, and continue to be, effective. A comparison of FPD in two contrasting environments shows how selection in a highly bio-secure environment can lead to improvement of the genetic merit under commercial conditions. Broad breeding goals including traits related to production, welfare, adaptability, liveability and reproductive fitness are essential to achieve a balanced progress in pedigree broiler lines. This approach has had and will continue to have benefits to the broiler industry globally.

SUMMARY

Phenotypic data from 25 years of selection for leg health showed that considerable improvements have been achieved for in three purebred commercial broiler lines through accurate scoring, a stringent culling policy and identification of families with superior leg health. Heritabilities for leg health traits in four contemporary purebred broiler populations were low to moderate and their genetic correlations with bodyweight generally somewhat unfavourable, but balanced selection, including, amongst others, production and welfare traits in a selection index, allowed continuous improvement of all traits. A comparison of foot pad dermatitis in two different environments showed that selection in a highly bio-secure environment can improve genetic merit under commercial conditions. Using broad breeding goals and contrasting environments has had and will continue to have benefits to the broiler industry globally.

Zusammenfassung

Zuchtfortschritte in der Beinqualität von Broilern durch Selektion in den Reinzuchtlinien

Mit der Beinqualität von Broilern haben sich Genetiker seit vielen Jahren beschäftigt. Eine Auswertung phänotypischer Daten über einen Zeitraum von 25 Jahren dokumentiert deutliche Fortschritte in drei Reinzuchtlinien, die durch eine Kombination genauer Bewertung, konsequentem Ausschluss von Kandidaten mit Beinproblemen von der Vermehrung und Selektion von Familien mit überdurchschnittlicher Beinqualität erreicht wurden. Obwohl die in vier Reinzuchtlinien zeitnah geschätzten Heritabilitäten der Beinqualität niedrig bis mäßig hoch und die genetischen Korrelationen zum Lebendgewicht minimal sind, konnten durch ausgewogene Berücksichtigung von Produktions- und Tierwohlmerkmalen im Selektionsindex in allen Merkmalen kontinuierliche Fortschritte erreicht werden. Vergleiche von Fußballenbefunden (FPD) in zwei unterschiedlichen Umwelten zeigte, dass die Selektion unter den Bedingungen des Zuchtbetriebes mit einem Höchstmaß an Biosicherheit auch zu Verbesserungen im kommerziellen Broilermastbetrieb führt. Zuchtplanung mit einer breiten Palette von Zuchtzielen für unterschiedliche Haltungsbedingungen hat in der Vergangenheit Vorteile für die Broilermäster gebracht und wird dies auch in Zukunft für die globale Broilerindustrie leisten.

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Focus on optimal starting conditions for day-old chicks

Hagen Müller, Regenstauf

Introduction

Legal guidelines of the European Community (EU) and national laws reflect the demand of consumers for safe food from healthy animals. Concern that the use of antibiotics in animal and poultry production may contribute to drug resistance in humans has resulted in efforts to reduce and eventually eliminate antibiotic treatments in poultry meat and egg production. In the following outline, we will focus on basic principles of chick management and call attention to mistakes which are still observed in practice. Understanding the needs of young chicks better and eliminating management mistakes can help to reduce the need for any drug treatments.

The principles are well known and explained in detail in every management program for meat-type and egg-type parent stock, but their importance is often forgotten in practice when tight working schedules dictate action. Even without consumer and legislative pressure to eliminate antibiotics from poultry feed, it is in the best interest of farm management to give day-old chicks a good start, and the principles discussed below apply anywhere in the world, especially where the climate includes cold periods. Investment in optimal starting conditions for day-old chicks is in the interest in terms of poultry welfare, minimal disease risk, low feed cost, environmental protection, sustainable use of resources and of economic interest to the farmer.

Chick management should start with fine-tuning procedures before the chicks arrive on the rearing farm. Optimal preparations for the arrival of the next batch of chicks will take more time and may be more costly, but it should pay for itself in terms of better results and reduced risk. Between placements is the best time to study mortality statistics from past flocks with chicks from the same hatchery, if possible across different farms, and to ask: what can be done to get even better results next time? The service staff of the hatchery will be happy to offer advice at this time instead of defending the hatchery and chick truck driver who probably did their job as close to perfection as possible.

The service staff should know the genetic potential of the birds from the results of well managed farms and can share information with those who are willing to learn and improve their own routine. Lessons from mistakes are a necessary part of “learning by doing”. With modern communication, it should be possible to identify and reduce the frequency of common mistakes. The following outline will address mistakes still seen too often on broiler farms.

Brooding – the first 10 to 12 days are critical

The first 10 to 12 days in the life of broilers are critical. If they are grown to a final live weight of about 2 kg, as is commonly the case in Germany, the brooding period represents a third of the growing period. Any stress during this early period, e.g. due to delayed placement after long transport, inadequate control of temperature and humidity, or access to feed and water, will make them more susceptible to infections, reduce growth and feed efficiency. Increased mortality is a reliable indicator of stress, but may be noticed too late to correct its cause. Stress will reduce the absorption of the yolk sack and maternal antibodies from the yolk. As a result, the development of the immune system will be delayed, and the full genetic potential for rapid weight gain and efficient feed conversion cannot be expressed.

A cold floor – the most common mistake

The favorite on our negative list is a cold floor. If we ask farm managers for data, we usually get figures for room temperature, measured anywhere above chick height, but seldom on the floor. Concrete floors are quite difficult to warm up, and the insulating effect of litter material needs to be taken into account. To guarantee a floor temperature of 30°C at housing, we recommend heating the house without any litter until the concrete floor reaches at least 26-27°C before a thin layer of litter is added.

Successful broiler growers try to combine the physical properties of concrete with the biological properties of young chicks into a strategy which resembles "floor heating": concrete can absorb and dissipate heat slowly, while young chicks depend entirely on ambient temperature and lose heat easily through their legs if kept on a floor with suboptimal temperature. The schedule for the different jobs between terminating one flock and housing the next chicks must allow adequate time for the concrete floor to warm up to the level chicks experience as comfortable.

How to measure temperature

Experienced stockmen used to be able to tell from the behavior of the chicks and their sound whether the floor temperature is acceptable. Today's managers may prefer to use fancy equipment to get exact temperature readings with a decimal point. But are they aware of the fact that an infra-red thermometer, held at a convenient height of 1.2 m above the chicks, measuring a floor temperature of 30°C, may be off by 3-5°C? We recommend taking at least three measurements, diagonally spaced through the house and directly on the floor.

During the winter months, the thermometer may take some time to warm up before the readings are accurate, and batteries should be changed before they are low and give inaccurate readings. If you don't trust the readings of your thermometer, take off your boots and walk the floor in your plastic overshoes: if your feet feel warm, the chicks are also likely to feel comfortable too.

Getting the chicks quickly on to the feed and water

To keep up with the development of labor saving technology in hatcheries and processing plants, the size of broiler operations have been growing over the years. New farms may have a capacity of 250,000 broilers, which are housed and depleted in a single day. If all goes well, a single person should be able to manage the farm throughout most of the growing period, and additional labor is only hired for peak demand at housing and at the end of each flock. Any additional personnel costs money, and qualified people may be difficult to get for a few hours, but the goal should be to house all chicks within 2-3 hours, ensuring the farm manager or the poultry specialist is always present. This can be organized with two chick trucks, the second leaving the hatchery one hour after the first truck, if 5-6 people are available for unloading and releasing the chicks into their new environment, where they can start to look for water and feed. Everybody understands that delayed access to feed and water is important with the short growing period for fast growing broilers. Seldom appreciated is that the air quality in the transport crates may not be perfectly controlled, and the chicks may either get cold or too hot. Any departure from the optimal temperature means potential stress, which must be minimized.

Air quality

You may remember old sayings like "more people freeze to death than are killed by poor ventilation", and some old-fashioned poultry managers still believe that chickens grow better under "hot house" conditions. Modern broiler growers should know better, but we find CO2 concentrations of 4.000-5.000 ppm, about twice the recommended upper limit. Trying to absorb rising energy costs by reducing ventilation rates would be "penny-wise, but pound-foolish". Apathetic chicks may be the result of inadequate oxygen supply, which may remind us of meetings in a crowded and poorly ventilated room, where we get sleepy and need a break. The chicks have to cope with given air quality 24 hours a day, and if they don't get enough oxygen, they will not eat enough and grow normally, and their immune system may be compromised for the rest of their life. Basic physics tells us that CO2 is heavier than oxygen, and excess CO2 at chick level means that there cannot be sufficient O2 to meet the chick's metabolic needs for optimal development. Investment in modern systems of renewable energy production and daily monitoring of air quality is becoming standard on modern broiler farms.

Innovative technology can be a trap

Several broiler growers who invested in biogas production to minimize heating cost complained about poor chick quality, "non-starters" with slow growth to 7 days of age and susceptibility to infections. Detailed on-farm analysis of a specific example on a farm identified the problem: since energy from biogas was very cheap, it was generously used to heat the concrete floor to the recommended 31°C; the room temperature was more than high enough at 35°C, and the CO2 concentration far below 2.000 ppm. Everything seemed "perfect" – except the humidity, which was only about 20%, far below the minimum of 35% recommended for chicks during the brooding period. With this low humidity, the chicks were dehydrated, appeared to feel cold despite the high temperature, many had obviously reduced feed intake, and the dry air had damaged their respiratory tracts. As an additional negative effect of the low humidity, the starter pellets had become hard and unattractive for the chicks.

Installing a spray cooling systems can correct this situation on such a specific problem farm, where the humidity was increased to 50-55%. Computer programs for modern cooling systems offer an option for „dust binding". Provided they are properly managed, they offer a simple and very effective method to optimize humidity. Since an increase in humidity will lower the temperature, care must be taken to set narrow limits for the desired temperature and to avoid excess humidity. First week results at that particular farm after installing the spray cooling system confirmed the predicted improvements: strong chicks with negligible mortality, excellent weight gain and uniformity resulting in a naturally healthy flock.

Risk of infections from contaminated litter

Day-old chicks can be susceptible to infections soon after hatch. Although every good hatchery will do its best to produce chicks with "healed navels", it would be a mistake to assume that chicks with dry navels can no longer be infected at the farm and we must remember chicks will arrive with a certain number of naturally occurring bacteria. The naval tissue is a sensitive area for some time after housing, and there is no way to prevent contact with the litter. In case the litter is dirty and contaminated with molds or any kind of bacteria, the chicks are likely to get navel or yolk sac infections. In some countries it is common to grow several flocks on the same litter, apparently with acceptable results after treating the litter for at least two weeks. For parent farms anywhere in the world and broiler growers in Europe we strongly recommend (1) final fumigation of all houses on the farm after thorough cleaning and disinfection to minimize the risk of carry-over infections between flocks and (2) starting each flock on fresh, soft, clean, dry and odorless litter to prevent infections from the contaminated litter. Straw may not always be available in desirable quality and other litter material like wood shavings significantly more expensive, but if an organization is determined to produce eggs or poultry meat without any antibiotic treatment, a higher price paid for good litter may be a good investment.

Summary

Theory and practice of early chick husbandry are discussed in the context of increasing public pressure to minimize and eventually eliminate the use of antibiotics in poultry production. Commonly observed mistakes are (1) floor temperatures below the recommended optimum at the time of chick placement; (2) monitoring house temperature high above chick level; (3) low humidity as a result of excessive temperature; (4) insufficient ventilation to save energy; and (5) yolk infections from contaminated litter. Broiler growers are encouraged to use a check-list to monitor the actual husbandry conditions in order to achieve the best possible results with minimal medication.

Zusammenfassung

Im Fokus: optimale Startbedingungen für Eintagsküken

Theorie und Praxis der Aufzucht von Küken in den entscheidenden ersten 10 Tagen wird mit Blick auf optimale Ergebnisse der Broilermast mit minimalem Einsatz von Antibiotika präsentiert. Als häufig in der Praxis anzutreffende Fehler wird besonders auf folgende kritischen Punkte eingegangen: (1) zu niedrige Fußbodentemperatur beim Einstallen; (2) Temperaturmessungen in einer für den Menschen bequemen Höhe statt am Boden; (3) zu niedrige Luftfeuchtigkeit, besonders durch überhöhte Raumtemperatur im Falle betriebseigener Produktion preiswerter Bioenergie; (4) apathische Küken infolge ungenügender Lüftung; und (5) Infektionen aus kontaminierter Einstreu. COBB Germany bietet Broilermästern einen Leitfaden für das Management an, der die obengenannten kritischen Punkte in einer „Checkliste für den Farmer“ praxisorientiert unter die Lupe nimmt.

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The challenge of cost effective poultry and animal nutrition: Optimizing existing and applying novel concepts

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Introduction

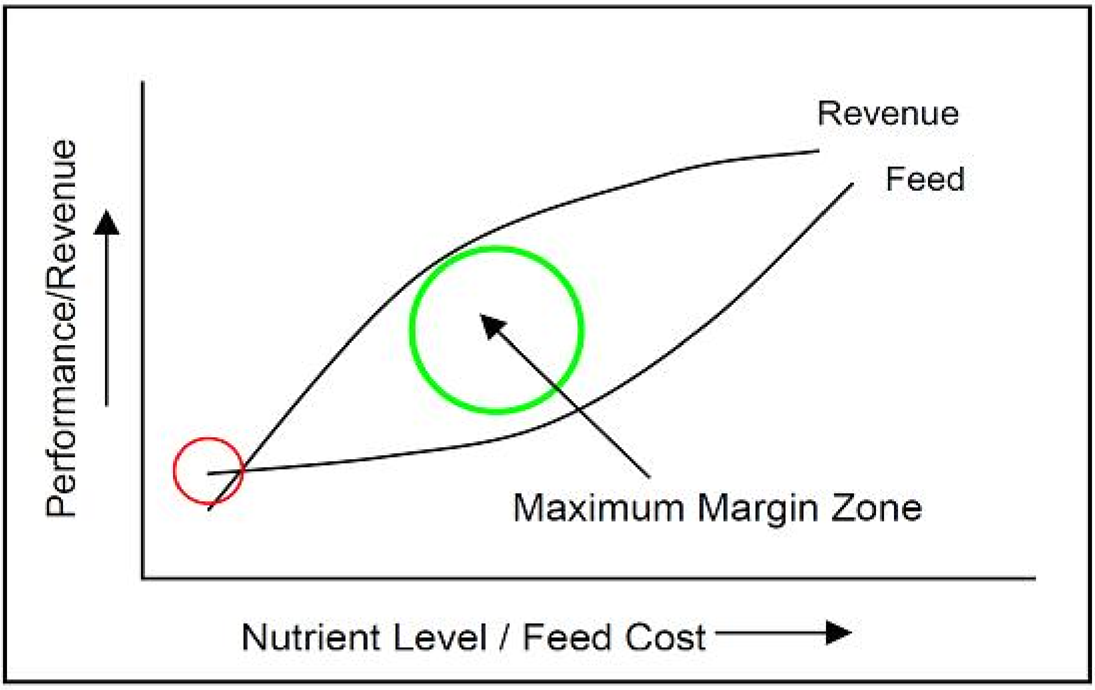
Feed accounts for 50-70% of the total costs in animal production. Any operation must therefore have clear targets how to optimize feed efficiency and reduce feed cost and work daily towards those targets. The sharp rise in feed ingredient prices in general, and soy bean meal in particular (Figure 1), has forced producers to refocus on what they spend on feeding, to raise efficiency targets and to go the extra mile for converting feed protein more efficiently into lean gain. In recent months ingredient prices have softened, easing the pressure somewhat, however, prices are expected to stay high and keep rising in the long term. There is no doubt that extra efforts are needed to optimize the use of feed in order to stay in business for the long run. The European industry, in addition, is heavily pressured to reduce the use of antibiotics and is facing increasing consumer demands for high quality, safe, welfare-friendly meat and eggs. These challenges mean that every link in the production chain has to be retuned regarding how we rear livestock and poultry in terms of nutrition, management and product use, while maintaining the focus on market demands. There is no magic solution to this challenging situation. When talking about sustainability of a production system, ecological and social aspects are major issues. However, in the current market, sustainability of livestock production in Europe is primarily threatened by not achieving the economic results a farm or a production system needs for longer term survival. No single change alone will bring about the improvement in nutritional efficiency needed. It is therefore necessary to reevaluate and fine-tune established nutritional concepts.

Figure 1: Average soy bean prices over the last five years (www.indexmundi.com)

Adapting dietary specifications for maximal net profit

The first critical point to verify and reflect on is dietary specifications. What level of energy, protein and amino acids do we need in different diets? The specification must not solely aim to keep feed cost as low as possible, or to maximize animal performance. Rather, they must be defined to yield maximum profit from the whole system. Figure 2 shows the relation between dietary nutrient concentration and feed cost, performance and revenue. Both revenue and feed cost increase with higher nutrient density in the diet (Waller, 2007). The green zone marks the area with maximal difference between the revenue curve and feed cost curve. When setting the nutrient levels in this range, the margin for 'revenue over feed cost' is highest. As feeding cost is a major production issue, this is also likely to represent the area with maximal net profit. A consistent production system with accurate data on animal performance and carcass value are needed to fine-tune the system. This basic information is available in most broiler operations, as bird genetics and the overall production system are well standardized. Many swine fattening farms also have such data available to define the nutrient concentrations which are most suited for their genetics and the market conditions they operate under.

Figure 2: Effect of feed dietary nutrient concentrations on feed cost, performance and revenue (Waller, 2007)

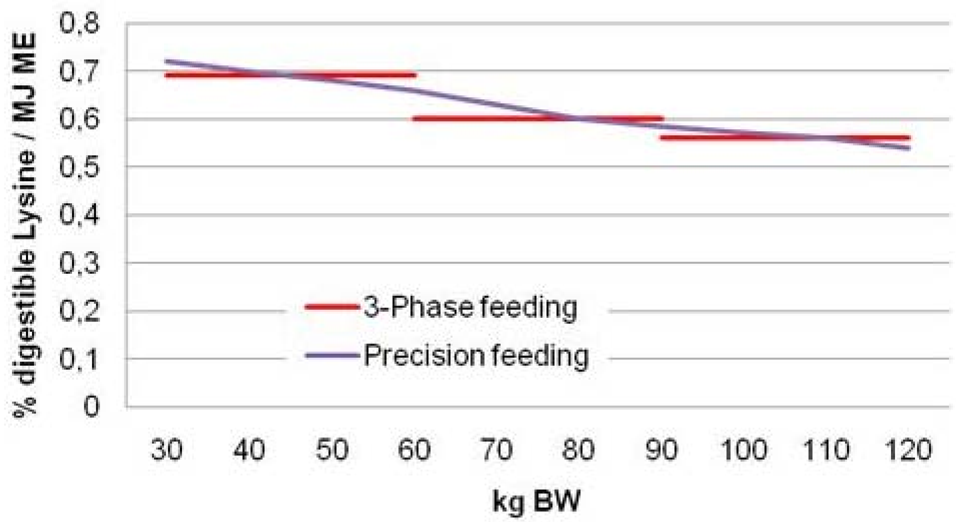


Feeding as close as possible to set specifications or requirement

High ingredient prices will raise the cost of safety margins and formulation inaccuracies. The current cost for protein is forcing producers to minimize safety margins. In order to keep safety margins low and, at the same time, avoid the risk of under-formulation, accurate knowledge of the quality and nutrient content of raw materials is essential. Ingredients have to be analyzed in as detailed a manner as possible and stored, blended and included based on quality.

As the requirement changes throughout the production cycle, feeding close to requirements and set specifications is more achievable with proper phase feeding. The current market situation might make it interesting to add an extra feed in the phase feeding program, i.e. to go from two to three or from three to four diets throughout the growth of the animals (Figure 3). However, the logistical cost for an additional feed and its storage has to be weighed carefully against any gains from feeding precision. Depending on the feeding system it might be worth looking at precision feeding by changing the ratio of a starter diet (being adapted to the requirements for the first day of the grower phase) and the finisher diet (being adapted to the requirement for the day before slaughter). With this approach, amino acid supply will exactly follow the change in requirement with no over- or undersupply at any time during the growing cycle (Figure 3). Liquid feeding systems or spot mix systems lend themselves well to this approach.

Figure 3: dLys/MJ DE with a 3-phase feeding system and with precision feeding with two diets with 0.72 and 0.54 g dLysMJ/ME where ratio is adapted each day to exactly meet the requirement of fattening pigs



For laying hens, in order to closely meet protein and amino acid requirements it is essential to have precise data on feed intake. The protein requirement of a healthy laying hen primarily depends on her body weight and production needs. However, energy intake is considerably affected by environmental temperature and locomotion. As birds adjust intake to meet their energy requirements, the amount of protein they need must be adjusted accordingly. If we formulate a diet to meet the requirement at an intake of 110 g/d, and the flock actually consumes 115 g/d, they will over-consume protein by about 5%, which will be wasted and contributes to extra ammonia emissions from the excreta. Under current market conditions the diet at an intake of 110 g/d will cost € 308.59 per ton and the diet for 115 g € 301.07 per ton (Table 1). Feeding the formulation for an intake of 110 g when birds are eating 115 g will result in extra cost of € 7.52 per ton of feed or € 31'500 for a 100'000-layer operation over a year. Automated and accurate measurement of feed intake should therefore be standard in any commercial layer house. If we consider having two diets on farm, one formulated to meeting the requirements when feed intake is high and one when it is low, then mixing those two diets accordingly will hit the requirements exactly.

Use of alternative ingredients

High soy prices make alternative ingredients more attractive. However, their availability is limited. When partially replacing soy bean meal, DGGS and rape seed meal, both by-products of the biofuel industry are of particular interest. However, their protein digestibility is lower compared to soy and can be more variable. Therefore, all formulations with alternative ingredients must be based on digestible amino acids. Formulations based on digestible protein and amino acids should be applied as standard in all diet formulations anyway. If operations are still formulating based on total amino acids, the inclusion of alternative ingredients is a good reason to adapt the system and modernize the approach to formulation.

Table 1: Effect of expected feed intake on feed specification, composition and cost in layers

	Predicted daily feed consumption	
	110 g	115 g
Feed composition		
Corn	38.64	44.21
Soybean meal	20.56	18.83
Wheat	19.97	15.52
DDGS Corn	8.00	8.00
Soya oil	0.95	0.64
Wheat bran	0.90	2.27
Other ingredients	10.98	10.53
Feed specifications*		
Energy, MJ ME / kg	11.40	11.40
Crude protein, %	16.82	16.09
Digestible Lysine, %	0.65	0.62
Digestible Methionine, %	0.33	0.31
Feed cost		
Ingredient cost (€ / ton)	308.59	301.07

* All specifications based on recommendations for Lohmann LSL-classic (Lohmann Tierzucht GmbH, 2013)

DGGS in particular poses a relatively high risk for mycotoxin contamination, thus raw material quality has to be controlled carefully. A comprehensive review on the use of DDGS in poultry has recently been published in World's Poultry Science Journal (Salim *et al.* 2010). The authors concluded that high quality DDGS can be fed to broilers, laying hens and turkeys without adverse effect on growth and performance. However, in order to maintain the consistency of DDGS quality from batch to batch, they recommended obtaining DDGS from a specific processing plant. For swine, Stein and Shurson (2009) have reviewed the literature and concluded that DDGS can be an excellent source of energy and digestible P in diets fed to swine at all production phases. Nutrient concentration and digestibility vary among sources, and accurate *in vitro* methods need to be developed to predict amino acid digestibility. Acceptable growth performance can be achieved by adding up to 30% DDGS in diets fed to grower-finisher pigs. Thus DDGS, when available at the right price and quality, can help to maximize margins over feed cost.

Since the levels of gucosinolates have been reduced in rape through genetic selection, rape seed meal or other by-products from the plant oil industry are potentially good protein sources for animals. Maximum levels of inclusion for monogastrics vary depending on the source of information, however most are in the range of 5 to 15%, although in diets for young animals, only low levels should be incorporated. Several German research institutes have compared pig grower-finisher diets with and without rape seed meal/cake inclusion (Priepke *et al.*, 2008, Frickh *et al.*, 1998; Weiss, 2008). Meyer *et al.* (2006) compared iso-nutritional diets with no rape seed cake or with 10% inclusion in a standard diet for pigs. They found no adverse effects of the rape cake inclusion on key performance parameters (Table 2). By-products from the plant oil industry will affect carcass fat quality. It should be monitored closely when using such by-products.

Table 2: Effect of rape cake inclusion on performance of grower-finisher pigs

	Control	10 % rapeseed cake
Performance until 50 kg BW		
Average daily gain, g	852	861
FCR	1.54	1.57
Performance overall		
Average daily gain, g	858	863
Feed intake, g	2.62	2.56
FCR	2.23	2.19

Several publications have reported cost savings by using rapeseed meal as a protein source. However, any such trial data have to be assessed taking into consideration current market prices.

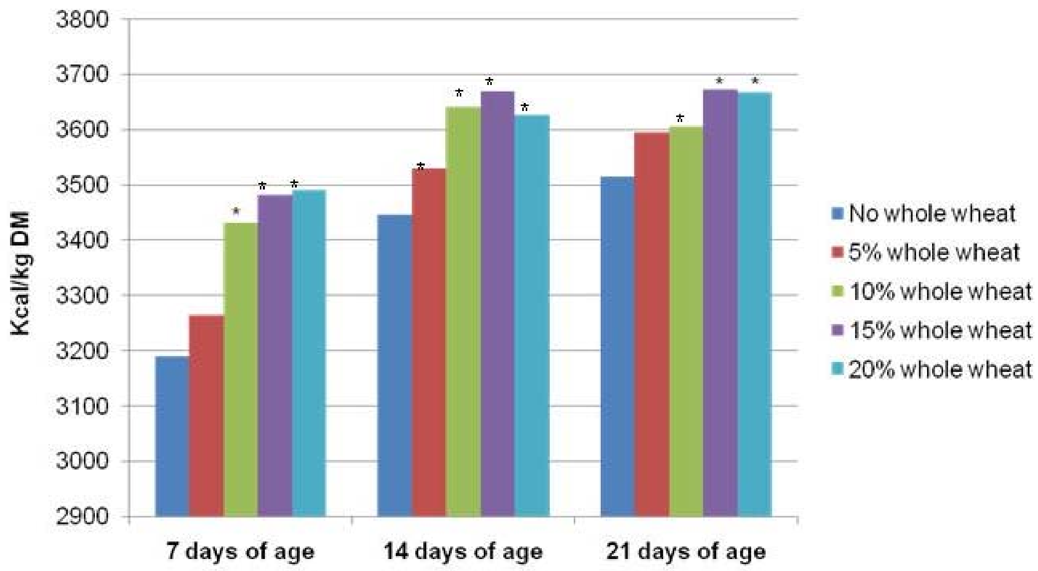
Maximizing diet digestibility

Taking measures to maximize diet digestibility in general, and protein digestibility in particular is important for several reasons. Firstly, high digestibility means a high amount of absorbed nutrients and thus efficient use of the feed. Secondly, high digestibility will reduce nutrient excretion and thus lessen the environmental impact from the livestock production system. Thirdly, high ileal digestibility will reduce the flow of protein to the lower digestive tract. This decreased flow of undigested protein can improve the gut environment and impact on intestinal health and immune defenses. In poultry diets, high protein concentrations have been shown to favor the proliferation of potential pathogens such as *Clostridium perfringens* (Drew *et al.*, 2004). High protein concentrations will also lead to increased uric acid in the excreta, which is known to be linked to higher litter moisture, and hence hock, feet and breast lesions. Thus protein digestion should be maximized and dietary protein concentration be kept low. In piglets, diets with decreased protein content have been shown to reduce the indices of protein fermentation and the incidence of post weaning diarrhea (Heo *et al.*, 2009).

Many different factors such as diet composition, quality of ingredients, diet processing and enzyme use affect diet digestibility. Grinding (particle size) and thermal treatment are the two key issues in the feed manufacturing process that impact diet digestibility. Pelleting and other thermal treatments can improve diet digestibility. In times of high feeding cost any increment in improved digestibility is worth more money and thus the economic impact of thermal treatment is larger in today's market with high ingredient cost. Particle size and overall feed structure is another factor to review and optimize. Research shows beneficial effects of whole wheat feeding on diet digestibility and production efficiency in broilers. The use of whole wheat has been shown to increase gizzard weight, and feeding 10% to 20% whole wheat can increase ME (figure 4) and amino acid digestibility (Biggs and Parsons, 2009). Whole wheat feeding is quite common in northern Europe. However, in the other parts of the world this approach still offers significant potential. The concept is particularly interesting for poultry farms that also produce wheat or farms which can buy wheat directly off the field from neighbor farms.

Digestive enhancers such as enzymes must be applied to their full potential. The final utility per unit used will decrease with higher inclusion levels; however, at high ingredient cost, higher inclusion levels can be justified. When feeding precisely on the requirement, it is likely more economical to assign a nutrient value to the enzymes and to reformulate the diet than to add the enzyme on top of an already formulated diet. Of course the change in utility per unit used with higher inclusion levels has to be properly taken into account.

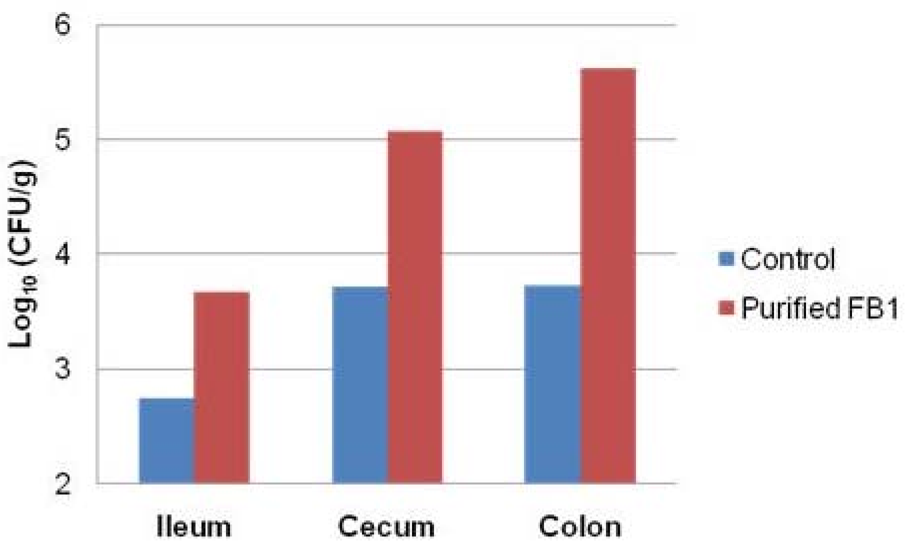
Figure 4: Effect of whole wheat feeding on energy utilization in broilers
(Biggs and Parsons, 2009)



Control of mycotoxins

Recently, animal feed had to be withdrawn from hundreds of farms in Germany and the Netherlands following the discovery of aflatoxin, a carcinogenic, in dairy milk. The mycotoxin was introduced into the feed via corn from Eastern Europe. This case once again demonstrated that transparency in the market combined with analytical control is key to guarantee feed and food safety. While aflatoxin, due to its transfer in animal products and its carcinogenic properties in humans, is strictly regulated with maximum legal limits, for other toxins only vaguer values for limits exist. However, as such toxins affect animal performance and health, their control is critical to optimize feed utilization (Zaki *et al.*, 2012). Fumonisin B1 (FB1) can cause increased translocation of bacterial pathogens across the intestine. In piglets, oral administrations of FB1 for seven days significantly increased colonization of the small and the large intestines by pathogenic *E. coli* strains (Oswald et al., 2003) and enhanced the bacterial translocation to extra-intestinal organs (Figure 5).

Figure 5: Oral administration of FB1 significantly increases the gut colonization of *E. coli*
(Oswald, *et al.*, 2003)



The control of mycotoxins starts with crop production. It is well established that crop rotation, cultivation practices (e.g. direct seeding enhances the risk for mycotoxin production) and the variety which is planted greatly affects the mycotoxin risk. In most situations, the feed producer does not produce their own crops, so good communication and market transparency is critical. To assess the mycotoxin risk, it is essential to know the source. Insufficient and excessive rainfall during critical phases of crop development can lead to mold contamination, spoilage of grain, and mycotoxin production. Also post-harvest handling of grain presents opportunities for controlling mold growth and its consequences. Careful drying of grains and good storage management should minimize post-harvest fungal growth and, therefore, mycotoxin production. If several factors point towards an enhanced risk for mycotoxin presence, or contamination has been confirmed by analysis, the inclusion of an additive or feed ingredient which has been shown to reducing the negative impact of mycotoxin should be considered (Chowdhury and Smith, 2004; Zaki *et al.*, 2012; Boudergue *et al.*, 2009). Very significant advances have been made over the last couple of years in mycotoxin analyses. Novel mass spectrometry techniques are commercially available which allow simultaneous analyses for up to 40 mycotoxins (http://www.mycotoxinmanagement.com/MIKO). This gives a much more comprehensive picture of the challenge a herd or flock is exposed to. A proper analysis of the situation is the key to put together and implement the most efficient package of measures.

Maximizing overall animal performance and intestinal health

Poor animal health is the most important factor that affects the efficient use of feed in commercial production systems. A recent study by Riklin and Hartmann (in press) shows that many farms have considerable room to improve management practices in order to optimize animal health, performance and welfare. Sollberger *et al.* (2013) determined that, on Swiss pig farms, during the grower-finisher phase on average 33% of feed protein was retained in body tissue. However, the variation between farms in protein efficiency was very large despite the use of comparable genetics and even when using similar diets. This clearly shows a huge potential for improving efficiency by optimizing animal health. Poor animal heath will depress feed intake and thus reduce the nutrient which are available to the animal. Disease will also increase the nutrient requirements for maintenance. This will reduce the nutrients which are available for growth and thus affect production efficiency. Maximal overall animal and intestinal health can only be achieved when housing, biosecurity, health management, nutrition and host defense are at its best. Many factors which have already been discussed can positively impact intestinal heath. Dietary specifications, ingredient choice, measures to maximize diet digestibility or to control the negative impact of mycotoxins can all contribute to better intestinal health. In addition, specific feed ingredients or feed additives can give vital extra increments of improvements. Their efficacy can be challenged when exposing animals under controlled conditions to disease. A recent trial from the University of Wageningen shows that Actigen™, a yeast cell wall based feed product, can reduce the impact of *E. coli* in weaning piglets. Not only was the ingredient able to reduce the concentration of the pathogen, those animals with reduced pathogen load and stress in the digestive tract, showed that feed intake was much less affected. This will reduce the growth check which typically occurs during such disease events. In poultry, a recently published meta-analysis demonstrated that using Actigen™ significantly and beneficially changed body weight by +0.080 kg (+3.34%), FCR or F/G ratio by -0.033 (-1.84%) and mortality % by -0.80 compared to a negative control (Hooge *et al.*, 2013).

Enhanced buying power

There is no single measure that will bring the improvements in efficiency the producers need in the current market. The entire system must be thoroughly reviewed and existing margins for improvement exploited in all areas of production. The efficacy of the different measures will vary from case to case with animal production systems. The only measure that can bring fully predictable results is buying the same quality feed at a lower price. Depending on the market situation, farmers have to work with large companies as trading partners and hence often lack leverage when it comes to buying and negotiation power. Pooling demand and approaching the market from a stronger position must be considered as an approach to improve farm profitability and assure the capability to invest in production operations and thus give the business a long-term future.

Summary

The global animal industry is facing severe economic pressure due to high prices of feed ingredients. The producers must push to make maximal use of the feed. In several markets, producers are heavily pressured to reduce the use of antibiotics and are facing increasing consumer demands for high quality, safe, welfare-friendly meat. These challenges force every link in the production chain to retune how we rear animals in terms of nutrition, management and product use. The present paper summarizes approaches to fine-tune the nutritional concept. Dietary specifications have to be reevaluated and phase feeding concepts optimized in order to maximize margin over feeding cost. If alternative ingredients are available at the right price they offer an interesting approach to reduce feeding cost. However, particularly when using alternative ingredients and reducing the dependency on antibiotics, intestinal health must become a key focus. Optimizing protein digestibility can help to minimize the intestinal problems. In addition, mycotoxin contamination must be dealt with and novel feed additives and feed ingredients considered. The entire system must be thoroughly reviewed and existing margins for improvement exploited in all areas of production.

Zusammenfassung

Die hohen Futtermittelpreise setzen Tierproduzenten und Futtermittelbranche unter enormen wirtschaftlichen Druck. Die gesamte Branche ist gefordert, zusätzliche Anstrengungen zur Futterkostenoptimierung zu unternehmen. Die Kostensenkung muss erzielt werden, ohne den Druck des Marktes nach weniger Antibiotikaeinsatz, höherer Produktequalität und –sicherheit und artgerechterer Haltung aus den Augen zu verlieren. Diese Herausforderungen zwingen alle Beteiligten in der Produktionskette die Ernährungs-:und Haltungspraktiken weiter zu verbessern. Der vorliegende Artikel fasst Ansätze zur Feinabstimmung der Fütterung zusammen. Zur Verbesserung der Marge in der Tierhaltung müssen Energie- und Nährstoffgehalte der Rationen kritisch hinterfragt und Phasenfütterungskonzepte weiter optimiert werden. Wenn alternative Futtermittel zum richtigen Preis erhältlich sind, bieten sie einen interessanten Ansatz die Futterkosten zu senken. Bei der Verwendung von alternativen Futtermitteln und gleichzeitigem Druck den Antibiotikaeinsatz zu reduzieren, muss der Darmgesundheit besondere Beachtung geschenkt werden. Eine hohe Proteinverdaulichkeit hilft das Auftreten von Verdauungsproblemen zu minimieren. Zusätzlich gilt es die Mykotoxinbelastung tiefzuhalten und die Darmgesundheit mit dem Einsatz spezifischer Futtermittel oder Futterzusätze weiter zu verbessern. Das gesamte System muss gründlich überprüft werden, um bestehende Spielräume zur Verbesserungen in allen Bereichen der Produktion nutzen zu können.

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Determining the optimum replacement schedule for commercial layers: does molting pay off?

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Introduction

Within given constraints, management decisions focus on overall profitability of the business. The profit from egg production for a farm or a specific flock of laying hens depends on many variables, including (1) market preferences for different egg size and management conditions, (2) availability of suitable rearing conditions, (3) disease control and nutrition throughout the life cycle, (4) pullet and spent hen prices, (5) seasonal variation in egg prices and (6) genetic potential of a given strain of laying hens. Historically, most flocks were housed annually, and egg production followed seasonal cycles. In Europe, most chicks used to hatch early in the year, and the custom of eating eggs "ad libitum" at Easter helped to utilize surplus production at peak rate of lay, while eggs were short in supply late in the year, when most hens went into a natural molt and winter pause.

Since the introduction of lighting programs, chicks can hatch throughout the year, and eggs can be produced to meet any demand. Today's commercial layers have the genetic potential to maintain high egg production and acceptable shell quality for more than 12 months, and producers can vary their placement schedules to maximize egg income over cost, depending on seasonal price cycles, preferences of retail chains and specific customer demand in niche markets.

The optimum length of a laying period has been the subject of many studies for more than 50 years and mathematical tools were developed to determine the optimum under defined assumptions (White, 1959; Yassin *et al.*, 2012). Kühne and Flock (1978) compared weekly egg production records of an early maturing vs. a later maturing strain to demonstrate substantial differences in lifetime profitability if the choice of strain is combined with the strain-specific optimum length of laying period. The theoretically "optimal" replacement schedule calls for keeping the current flock in production as long as its weekly contribution margin exceeds the expected average weekly contribution margin of a new flock. However, these model calculations ignore seasonal variation in monthly egg income, which may be important if these effects are predictable.

Since the study of Kühne and Flock (1978), the persistency of egg production and shell strength has been significantly improved in modern strains of laying hens and more computerized data are available on daily feed intake in environment controlled egg production units. Bell (2012) recently analyzed and commented the performance of LSL Lite flocks under US conditions, focusing on the variance between flocks during the first laying cycle up to 60 weeks of age, when many egg producers in the U.S. traditionally molt their flocks. In the current analysis we will focus on factors determining the optimum length of the laying period and answer the question whether it pays off to molt LSL Lite layers. We answer this question by annualising the contribution margin of flocks housed for one and two cycles.

Results

The final report of the 38th North Carolina layer performance and management test (Anderson, 2012) includes valuable information on the question of molting under U.S. conditions. This 83-page report contains 64 tables and 19 graphs with detailed results from 11 white-egg and 7 brown-egg strains, housed at different densities and exposed to different management alternatives. Table 1 shows the average egg income minus feed cost for all white-egg and all brown-egg entries across two cage densities; results for a control line are also shown as a measure of genetic progress.

Table 1: Egg income over feed cost (IOFC) per hen housed depending on the length of the laying period and after non-anorexic molting

Strain of layers	119 – 483 d	119 – 595 d	119 – 763 d not molted	119 – 763 d molted
All 11 white	14.37	20.24	20.42	22.76
All 7 brown	13.18	17.17	18.46	20.42
BPR control	2.88	3.32	1.34	n.a.

(Source: Adapted from Anderson, 2012)

The results in this table suggest what is widely accepted in the U.S. egg industry: the egg income over feed cost is higher if the hens are either kept beyond 12 months of lay in a single cycle (68 instead of 52 weeks), or kept for a second cycle after a non-anorexic molt at 69 weeks of age (instead of keeping the hens to 109 weeks of age without molting).

But this is only half of the story and tells us little about be optimum placement schedule unless we convert the IOFC figures from table 1 to annual production. These results are shown in Table 2 and will probably surprise egg producers who are convinced that recycling is good business for them.

Table 2: Annual egg income over feed cost (IOFC) per hen housed depending on the length of the laying period and after non-anorexic molting

Strain of layers	119 – 483 d	119 – 595 d	119 – 763 d not molted	119 – 763 d molted
All 11 white	14.37	15.52	11.57	12.90
All 7 brown	13.18	13.17	10.46	11.57
BPR control	2.88	2.55	0.76	n.a.

(Source: Adapted from Anderson, 2012)

If a single cycle to 85 weeks (595 days) of age were close to the optimum, we should not expect good business people to prefer recycling. Have we overlooked something? In order to get a more realistic estimate of maximum annual IOFC we have to take weekly egg income and feed cost into account. In the following calculations, we will use the standard for LSL Lite in North America. The input parameters and conclusions may differ for other strains.

Egg income is calculated from the weekly rate of lay, percentage of second grade eggs, average egg weight and the corresponding percentage of eggs in the different size categories according to the breed standard for LSL-Lite in North America (LTZ, 2012) and egg prices according to Table 3; spent hens are assumed to have no market value.

Table 3: Egg grades, size categories and US prices

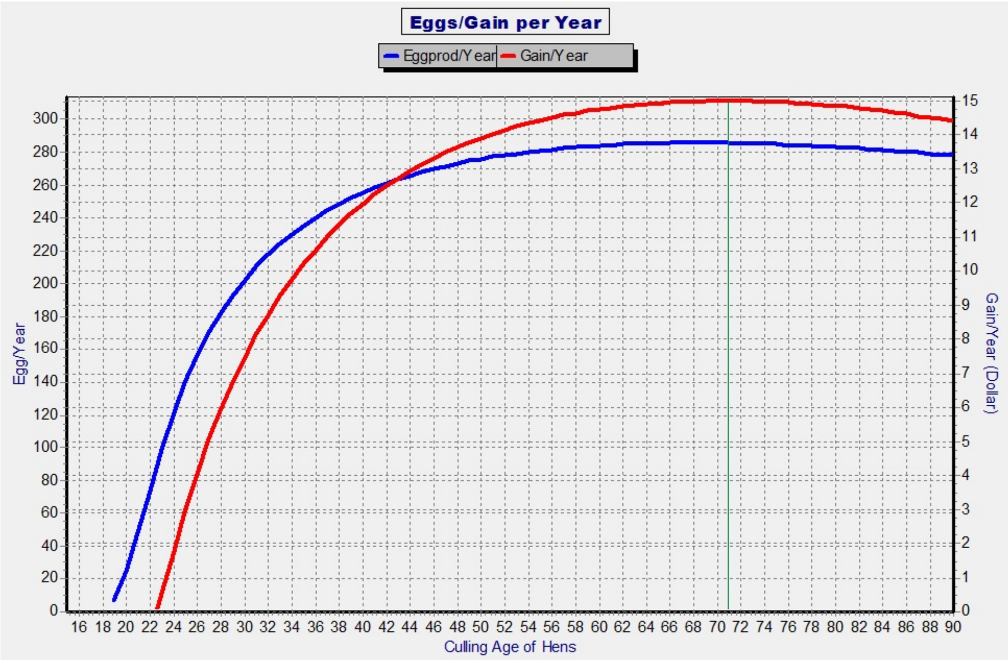
Grade	Size	Size category (grams per egg)	Price cent per egg
A	Extra Large	> 64	9.92
A	Large	56 – 64	9.67
A	Medium	50 – 56	7.75
A	Small	42 – 50	6.58
A	Pee Wee	< 42	3.25
B	All	All	80 cent per kg

Source: Adapted from Anderson, 2012

Weekly feed costs are calculated from the breed standard for daily feed consumption and a fixed price of 350 $ per ton, similar to the average feed price during the first cycle in the North Carolina test.

Which length of laying period would these calculations suggest as optimum to maximize annual IOFC? Chart 1 suggests a maximum of approx. 15 $ per hen place and year if the flock is terminated at about 71 weeks of age. However, this is not yet the optimum replacement schedule.

Chart 1: Annual egg production and annual IOFC per bird place and year depending on culling age of the flock



To get closer to the optimum replacement schedule, we have to take pullet cost into account. Other variable costs like labor, energy, water or veterinary costs will reduce the contribution margin, but are negligible in terms of the optimum length of laying period. We assume four weeks down-time between flocks, without considering extra cleaning costs.

Chart 2: Effect of pullet price on optimum culling age and annual egg income minus feed and pullets costs per bird place and year

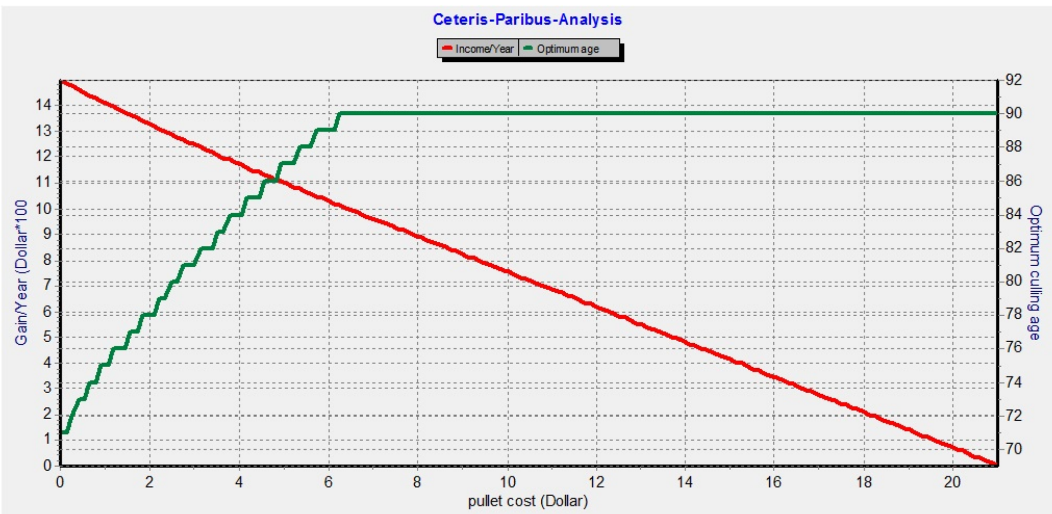


Chart 2 shows the general effect of pullet price on optimal replacement schedule, with pullet prices exceeding the range found in practice. Obviously, high pullet prices (or shortage of pullet rearing facilities) will be a strong argument for a longer laying period. Assuming a pullet price of 5 $, annual egg income over feed and pullet cost would be optimized at a culling age of 86 weeks.

So far we only considered housing for a single cycle up to 90 weeks of age. Chart 4 shows the results of IOFC optimization allowing a second cycle up to a total age of 115 weeks based on the performance standard shown Chart 3.

Chart 3: Standard performance of LSL-Lite during two cycles up to 115 weeks

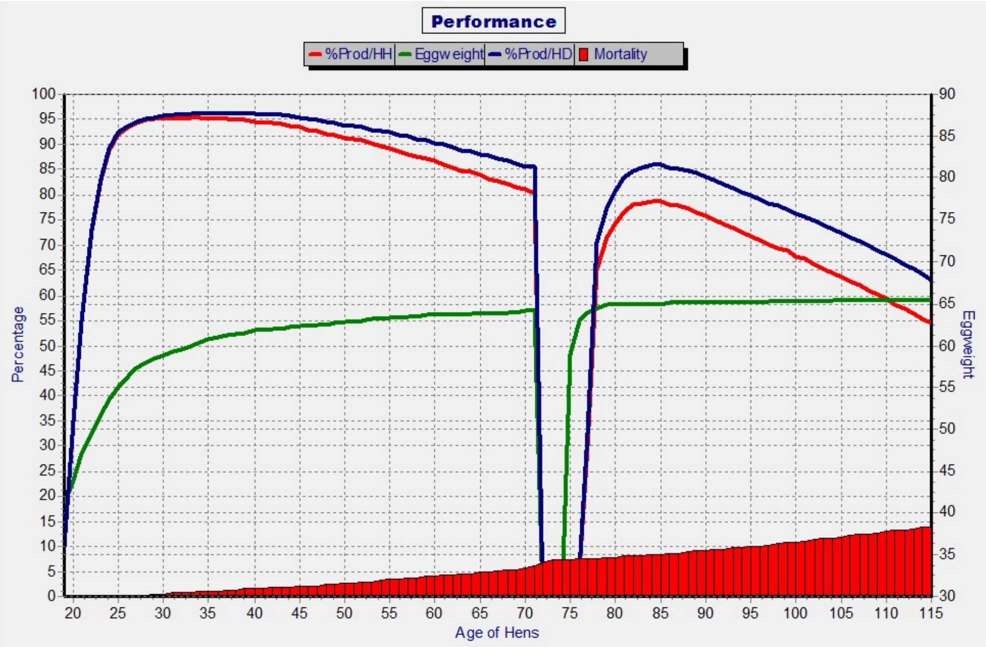


Chart 4: Eggs per year and annual IOFC depending on the culling age of the flock (two cycles)

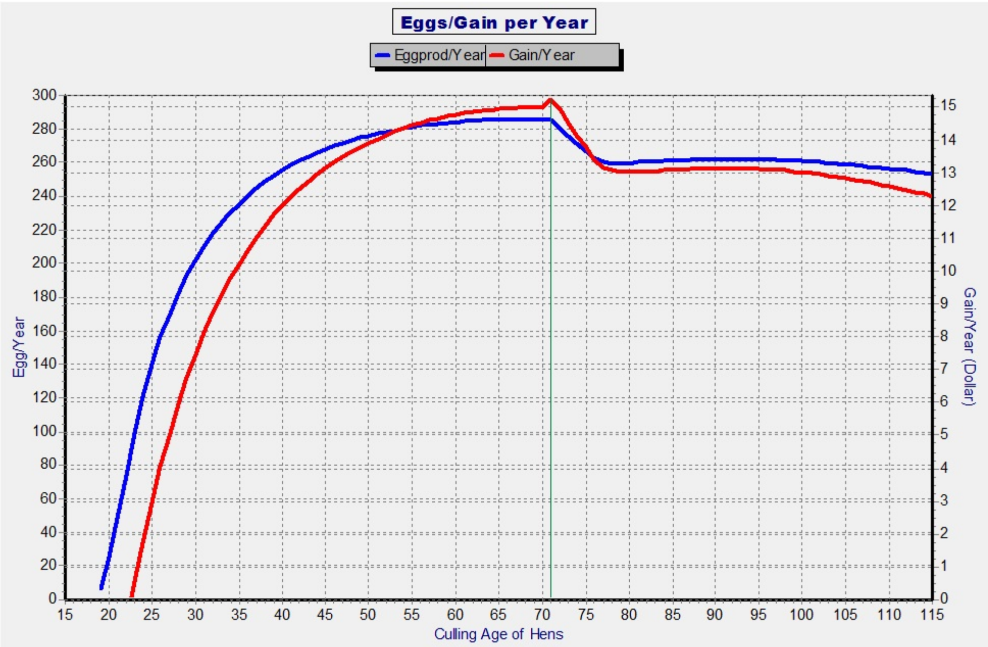
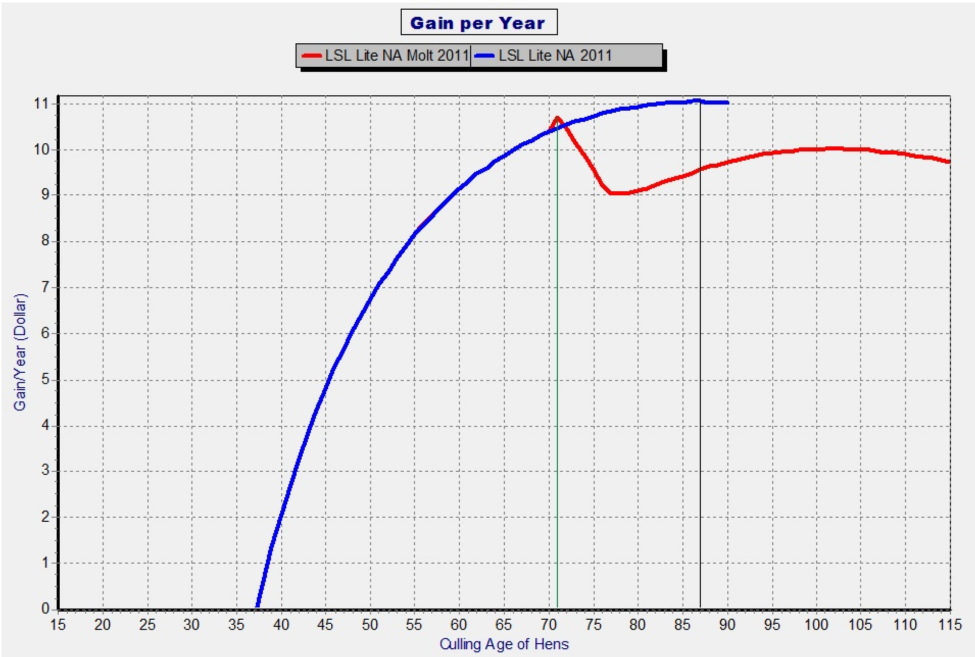


Chart 4 only shows that it would not make sense to molt if pullet cost could be ignored. Chart 5 shows what happens if a pullet price of 5 $ is included in the calculations. The egg income minus feed and pullet costs reaches a second peak after the molt, with a rather flat top of the curve around 105 weeks of age. However, this second peak is one dollar lower than the optimum for a single cycle to 86 weeks of age.

Chart 5: Annual egg income minus pullet and feed cost per hen place for single cycle to 90 weeks vs. two cycles to 115 weeks of age



The results of our model calculations show that LSL-Lite hens may reach an optimum in a single cycle around 85-90 weeks of age or a somewhat lower annual egg income over feed and pullet costs around 100-105 weeks of age.

Despite the economic advantage of single cycle production demonstrated in Chart 5, recycling flocks may be preferred as a means to increase average egg weight. The expected differences in grading results are shown in Table 4. A predictable demand for extra large eggs at a premium price may justify molting.

Table 4: Calculated percentage of eggs in different size categories depending on culling age

Size	Size category (grams per egg)	Single cycle up to 85 weeks	Two cycles up to 109 weeks
Extra Large	> 64	34.3 %	40.2 %
Large	56 – 64	50.6 %	47.3 %
Medium	50 – 56	11.4 %	9.5 %
Small	42 – 50	3.3 %	2.6 %
Pee Wee	< 42	0.3 %	0.3 %

Summary and conclusions

When we published results of our first analysis on optimal length of laying cycles, under conditions of the German egg market 25 years ago, considering only a single cycle, it was concluded that about 1 DM per hen place per year more could be earned if a strain with persistent production were kept for an extended laying period. Since then, the persistency of egg production has been further increased, and we extended the question to include molting as a possibility. Our calculations are based on a defined set of assumptions.

When results from the North Carolina Management Test were converted from life time egg income over feed cost (table 1) to annual figures (table 2), a significant advantage of a long single cycle to 85 (instead of 72) weeks was apparent for white-egg layers, but not for brown-egg layers. Molting did not improve annual IOFC per hen place.

The question of optimum placement schedules with one or two cycles was further analyzed, including pullet costs, based on U.S. egg and feed prices and performance standards for LSL Lite hens in North America. The final results are shown in figure 5 and table 4: a single cycle to about 85 weeks of age can increase annual egg income over pullet and feed cost by about 1 U.S $, compared to about 105 weeks of age after molting.

Results for other strains (especially less persistent or brown-egg strains) may differ. Molting can be economical if pullet prices are high and/or premium prices are paid for large eggs. The Global Competence Team of Lohmann Tierzucht will be happy to answer questions.

Zusammenfassung

Optimale Haltungsdauer von Legehennen - lohnt sich eine Mauser?

Die Entscheidung über die Haltungsdauer von Legehennen kann in hohem Maße die Profitabilität der Legehennenhaltung beeinflussen. Ergebnisse aus dem 38. "North Carolina Layer Performance and Management Test" zeigen klare Vorteile einer Mauser gegenüber gleich langer Haltung bis zum Alter von 109 Wochen, wenn man nur den kumulativen Eiererlös minus Futterkosten zugrunde legt (Tab. 1). Wenn man jedoch die Jahresleistung betrachtet, verschiebt sich das Optimum und erreicht ein Maximum bei 85 Wochen Schlachtalter (Tab. 2).
Wir haben in unseren Berechnungen für die Herkunft LSL Lite die Standards für Nordamerika zugrunde gelegt und auch die Junghennenkosten berücksichtigt. Demnach kann eine Einphasenhaltung bis etwa 85 Wochen pro Hennenplatz und Jahr etwa 1 U.S. $ mehr Gewinn bringen als Zweiphasenhaltung bis etwa 100-105 Wochen (Abb. 5). Diese Ergebnisse sind nicht auf andere Herkünfte zu übertragen. Hohe Kosten für Junghennen und/oder besonders attraktive Preisen für XL Eier sind Argumente für Mauser; Argumente des Tierwohls sprechen gegen Mauser.
Wer die wichtigsten Leistungsdaten für seine Herden wöchentlich erfasst, kann aus eigenen Daten in Modellrechnungen das betriebsspezifische Optimum ableiten. Erfahrene Mitarbeiter des Global Competence Teams der Lohmann Tierzucht bieten hierzu gerne Hilfestellung an.

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Longevity of high producing dairy cows: a case study

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Introduction

In 2011, 4.19 million dairy cows produced 10.148 billion Euro worth of milk, which accounted for 43.3% of income from farm animals and 19.4% of total farm income in Germany (ADR 2012).
Milk yield per lactation across all breeds was about 7,000 kg and total annual milk production was about 28 million tons, which covers the domestic demand and reflects the importance of milk and milk products for human nutrition in Germany.

To keep up with national and international competition, milk production per lactation has been increased from 3,500 kg in 1970 to 7,000 kg in 2011 (ADR 2012). This increase is due to improved genetic selection, combined with adapted nutrition and health service, and is no doubt a success story of modern agriculture.

High lactation yield is only one essential component of successful milk production, the economics of dairy farming also depends on longevity of the cows.

The average productive life time has declined from about 3.5 in 1970 to currently between 2.5 and 3.0 lactations, in opposite direction of the increasing milk yield. That means many cows leave the herd already after 2-3 calvings, before reaching the maximum of their production capacity. Swalve (2012) reported first indications of a reversing trend.

The high annual replacement rates show significant regional and farm-to-farm variation. Depletions are already high during the first lactation. Bergk and Swalve (2011) reported 10.7% losses during the first 300 days p.p. and 20.9% by 450 days after first calving.

Similar results were found by Münch und Richter (2012) who analyzed the reasons for culling 25% of first lactation cows in Baden-Württemberg. Infertility was the most frequent cause (20.9%), followed by mastitis (14.3%) and lameness (11.0%).

We do not have reliable statistics for deaths of dairy cattle in Germany, but they should be included in our assessment of the situation. Research in the USA indicates an increasing rate of mortality (> 5 %), which appears to be positively correlated with milk yield (Miller et al., 2008, Alvåsen et al., 2012). Taking also the mortality of calves into account, which is sometimes be quite high (> 15 %), it may become difficult to replace the own herd.

The problem of short utilization and high rates of culling has been critically reviewed by Rauw et al. (1998) and Berry et al. (2007). Causal relationships were studied in more detail by Ingvartsen (2006) and Mulligan und Doherty (2008); Martens (2007) focused on the impact of metabolic stress for high yielding cows.

An important conclusion from these analyses is the great variation of observations under identical conditions and with the same level of production (Ingvartsen et al., 2003), i.e. the numerical results are correct, but they ignore the positive exceptions.

As we all know, some high producing cows or whole herds are remarkably healthy and are kept for many lactations. This is illustrated in the recent publication by Iwersen (2011).

The frequency of diseases during the first 70 days p.p. was registered in a high yielding herd (258 cows averaging 11,049 kg/ lactation). Exactly 2/3 of the cows had a problem, 1/3 had no health problems. Understanding what enabled the healthy third of the herd to sustain high production during a longer productive life may tell us at least as much as analyzing the pathogenesis of the diverse peripartal diseases and causes of mortality. Hence, our current description of the management of a herd with high milk production and longevity may offer other dairy farmers useful ideas how to improve their results.

Dairy Farm Soonwald in Seibersbach

General information: Soonwald Dairy Farm is a family farm owned by the Bange family since 60 years, who keep 145 head of cows and a corresponding herd of about 140 heifers. The herd includes red and black German Holsteins. They farm 140 hectares arable land, of which 50 ha are owned and 90 ha are leased.
95 ha are used as pasture and 45 ha to grow crops, 50% of which to produce feed for the cattle. The work force consists of husband and wife of the owner family, one full-time employee and one trainee.

Performance parameters: The current herd of 145 cows was built up gradually from own progeny and is intended to be increased to 150-155 cows in the near future. The average lactation yield peaked at 11,000 kg in 2002 and was reduced to 9,500 kg since then in order to make the herd more manageable.
Lifetime yield per cow is currently 36,000 kg milk with 4.23 % fat and 3.38 % protein. The average productive life was for many years 4.5 lactations and is currently down to 3.5 lactations, due to keeping more heifers while increasing herd size.
The average lactation curve is rather flat, with peak production 8 weeks after calving. The average length of lactations is 11-13 months, with calving intervals of 420-430 days and dry periods preferably 6-7 weeks.
The depletion rate (culling) averages about 15%. Currently all heifers are kept to increase the herd of milking cows. Cows which have produced 100,000 kg milk are usually not slaughtered but euthanized. Sudden death is extremely rare.

Management of dry cows and calves: Dry cows are kept in two groups and moved into one of four available calving pens, with sight contact to the other cows, when they are about to start calving. Calving is not systematically supervised, and cows are only assisted if necessary (about 90% calve without help).
The new borne calf stays with the mother for up to 12 hours before it is moved into an igloo for 2.5 weeks and finally joins other calves in a group pen. Within the first 3 hours the calves get 2-3 liters colostrum. In case the cow does not give enough colostrum, there is always a reserve in the freezer.
Only about 4% of the calves are stillborn or die during calving. Rearing losses are not significant. Bull calves with superior pedigree are reared and sold for breeding at the age of 12-14 months. The other male calves are sold at about 2 weeks of age.

Health care: The farm has no prophylactic health care program for the herd and follows the traditional practice of calling on a veterinarian to treat individual animals which are sick. The cost for veterinary treatments averages about 80 Euro per animal per year.
This refers to common treatments. The incidence of metritis or mastitis is low. The non-return rate with farm-own AI is remarkably good, with 1.7 and 1.8 inseminations per calf born alive for first-calf heifers and older cows, respectively. The culling rate for infertility reasons is therefore very low. Synchronization of estrus and insemination is not practiced on principle.
The claws are trimmed 3 x per year by an experienced claw trimmer. Prophylactic claw baths are not provided. *Mortellaro* continues to be a problem and is treated as soon as it is recognized; the same goes for other causes of lameness.

Housing and feeding: In new barn with open boxes and a milking robot was installed. The gangways are extra wide (5.2 m) to allow high ranking and low ranking cows to pass each other without any problem. The side walls are also higher than usual (5.0 m) to optimize lighting and ventilation. The resting places get new litter (short cut straw) every day and are checked twice a day (to keep it clean with a bed of straw).
The number of resting (160) and eating (200) places exceeds the number of cows significantly to make sure all cows can eat, drink (15 automatic drinkers) or rest. The milking robot is not used optimally by all cows, and 10-12% of the cows have to be driven into the system. This extra work is accepted as necessary (see below).
The feed consists of a roughage mix (table 1) and up to 5 kg added concentrate (19/IV for high producing dairy cows), allocated according to current milk production. This additive is mixed and pressed according to specifications of the dairy farmer. The allocation is based on the transponder ID of each cow while she visits the milking robot. Remarkably high is the intake of roughage, aver-

aging above 20 kg DM per day. The roughage mix is offered fresh once per day and kept easily accessible.

Table 1: Components and contents of the base ration

Component	Komponente	%
Gras silage	Grassilage	47.4
Corn silage	Maissilage	21.2
Beet pulp	Pressschnitzel	18.0
Distillers grain	Biertreber	8.2
Alfalfa meal	Luzerneheu	1.6
Straw	Stroh	0.5
Rape seed meal	Rapsschrot	1.3
Rape seed	Raps	1.3
Yeast	Hefe	0.2
Minerals	Mineralfutter	0.3

Contents	Inhaltsstoffe	% DM
Drymatter (DM)	Trockensubstanz	32.0
Crude protein	Rohprotein	15.8
Fiber	Rohfaser	20.3
Crude fat	Rohfett	3.35
Starch + sugar	Stärke + Zucker	13.2
ADF	ADF	24.3
NDF	NDF	39.5
NFC	NFC	33.7
MJ NEL/kg	MJ NEL	6.7

Perspectives and goals of the dairy farmer: The milk yield of this herd is significantly above average, but not as high as on farms focused on maximum milk yield. Top milk yield had been achieved some years ago in this herd as well, but only with higher expenses. The current goal is no longer to maximize average lactation yield, but lifetime productivity.
Desired is a further increase of the number lactations per cow, although the current herd average is already significantly higher than in the national cow population. In other words: not highest possible milk yield, but high milk yield in combination with consistent health and longevity. The experience on this dairy farm shows that cows with 100,000 kg milk yield lifetime performance are a realistic goal. After the herd size has been increased to 150-155 cows, it is planned to sell 35-40 first lactation heifers per year, like in previous years.

Conclusion

Economic milk production should combine high milk yield and longevity. Lactation yield has been increased significantly during the past decades, but at the expense of productive life span. This is generally recognized, but too little attention is paid to positive exceptions from the general trend like illustrated in this case study. As shown on the dairy farm of family Bange, above average milk yield can be combined with exceptional livability. The following tentative conclusions are offered:

a. *Experience:* The family has operated this dairy farm successfully for decades and expanded gradually while improving the results from year to year. After reaching top milk yield, it was decided to reduce milk production.

b. *Management of the herd and checking:* The cows are handled with utmost care: separating the calf from the mother within 12 hours; wide gangways to enable cows to pass each other; straw in the resting boxes, which are serviced frequently; herding individual cows into the milking robot in case they don't use it sufficiently. All this contributes to continuous observation and corrective action if necessary.

c. *Nutrition and resting:* The high intake of roughage (>20 kg DM/day) contributes significantly to the productivity of the cows. Limiting concentrates to 5 kg/day means that these cows are fed as ruminants (table 1: high fiber content, relatively low starch and sugar levels). Ample space allows the cows to choose what they like to do, wide gangways to prevent blockage by high ranking individuals.

d. *Expected performance:* Selection for high milk yield has resulted in higher early production and rapid increase toward peak daily milk yield. Delaying the peak to 8 weeks after calving helps to adjust feed intake (Gravert, 1985) and metabolism gradually at a time when fertility problems are frequently encountered (Harrison *et al.*, 1990). As a consequence of more or less parallel increase of milk output and feed intake, the duration and intensity of negative energy imbalance are reduced so that NEB associated disorders like ketosis (Baird, 1982), fatty liver (Herdt, 2000; Geelen and Wensing, 2006), immunosuppression (Goff, 2006), lameness (Bicalho *et al.*, 2009), infectious diseases (Sordillo *et al.*, 2009) and fertility problems (Butler, 2003) are less frequent or unknown in this herd of cattle.

Without induced synchronization of estrus and planned AI, calving intervals are longer, but the preference for natural development appears to be beneficial. With lower first lactation milk yield, the heifers can invest more into a strong constitution which enables them to increase production in subsequent lactations.

Outlook: The primary goal is no longer maximum milk yield (in the first lactation), but a balanced combination of high average lifetime milk yield, longevity and health of the cows.

Summary

A commonly recognized problem of modern dairy farms is that the extremely high milk production often leads to a shorter productive life so that it becomes difficult to maintain the herd size from own replacement heifers. The herd management of a dairy farmer in Germany is described as a case study to show that competitive family income can be achieved by focusing on a combination of high milk yield, longevity and health of the cows instead of on maximum milk production at the expense of other equally important traits. The practical experience of the owner family, focus on wellbeing of the herd and health care for individual cows, a nutrition program designed for high intake of roughage and continuous checking in the cow barn while the cows use the milking robot are seen as essential factors in this successful dairy operation.

Hohe Leistung und lange Nutzungsdauer von Milchkühen:
Ein Praxisbericht

Extrem hohe Milchleistung und erhöhte Abgänge wegen Unfruchtbarkeit oder anderer Ursachen in modernen Kuhherden werden in ursächlichen Zusammenhang gebracht. In dieser Fallstudie wird ein Familienbetrieb mit 145 Kühen und eigener Nachzucht beschrieben, der bewusst von maximaler Laktationsleistung auf hohe Lebensleistung in Kombination mit guter Gesundheit und Lebensdauer umgestellt hat. Als Erfolgsfaktoren werden langjährige Erfahrung, tierfreundliches Management in einem modernen Boxenlaufstall mit Melkroboter, ein spezielles Fütterungskonzept mit hohem Anteil Raufutter aus eigener Produktion, laufende Beobachtung der Tiere und kurzfristige Reaktion auf alle individuelle Gesundheitsprobleme herausgestellt.

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