



## Review

## Developments in welfare of parent stock and commercial broilers

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## ABSTRACT

Meat poultry breeding plays a critical role at the start of the food chain. Breeding solutions are long-term – as available in the DNA of the populations. They are also cumulative – the gradual improvements add up –, and disseminated widely throughout the production chain. Poultry meat is an important animal source food, and instrumental for global food security. The contribution that poultry breeding makes to meet current and future needs can be described in terms of a Code of Good Practice for Sustainable Breeding (Code-EFABAR®), and as Five Commitments to 1) Health, Food Safety and Food Security; 2) Diversity; 3) Balanced Breeding; 4) Management and Stockmanship; and 5) Transparency, Communication and Engagement. The review describes these commitments. Understanding what future directions are foreseen in the medium and long term is the basis for change. The dialogue and close cooperation with stakeholders in society is crucial to anticipate developments, by investigating and implementing them in steady and careful balanced selection leading to better welfare, productivity and sustainability outcomes.

## GLOBAL DEVELOPMENTS

It is expected that the global population will increase to 9.7 billion in 2050 (United Nations, 2024) and the amount of agricultural land per person will drop from 1.4 to around 0.2 hectares per person (United Nations, 2024; Our World in Data, 2024 a, b). With around 140 Mt (carcass weight equivalent (cwe)) produced globally (OECD/FAO 2024), poultry meat is the most important land-based animal sourced food (ASF), followed by pork (122 Mt cwe). Poultry meat is estimated to grow from 2024 to 2033 with 1.4 % annually to 160 Mt cwe. Poultry consumption increases regardless of country income expressed as Gross Domestic Product (GDP) (OECD/FAO 2024).

ASFs contribute to healthy diets globally. They contain high and bioavailable contents (e.g., essential fatty acids, folic acid, iodine, vitamin A, zinc). They are the only natural dietary sources of vitamins B12 and D, and all essential amino acids are available in the ratios the human body needs. This makes them an important food source for vulnerable people (children, adolescents, reproductive and pregnant women and the elderly) (Clapp et al., 2021; Miller et al., 2022), in particular in lower and middle-income countries. For the intellectual development of young people, ASFs are instrumental. Hulet et al. (2014) showed that providing meat as part of a mid-morning school snack in Kenya gave steady boosts in school results. Children getting

meat were having 17% higher school scores than the average of four snack options: no snack, vegetables, milk, meat. In particular, students were better in language, geography and science learning. Poultry meat has the additional advantages that it is affordable, lean, has a low environmental impact (OECD/FAO, 2024), and is consumed across most cultures and religions (Adler & Lawler, 2012).

With societies becoming more affluent, and less people working in farming, the distance between food producers and consumers increases. And perception of animal welfare by humans may differ from the welfare animals can perceive themselves (Kite, 2018). As Dawkins (2012) and Grandin (2023) indicate, welfare must work out for the animal in the field, focus on science, appreciate the critical role humans play in animal welfare, and not be led by anthropomorphism of claims of animal consciousness. Welfare perception by humans is important for societal acceptance; however, the ones experiencing welfare are the chickens.

## Breeding role and responsibility

The increasing requirements from the markets, and society, for more, healthy, responsibly produced food require breeders to ensure these needs can be met at the short and longer term. As breeders are situated at the start of the supply chain.

Breeding chickens has a long history. Humans have selected farm

Animal Well-Being and Behavior **A breeder's point of view**

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animals since the early days of domestication for characteristics that suited their needs, e.g., surveillance, meat production. Reports of chicken domestication from the Red Jungle Fowl (*Gallus gallus*) stem from Neolithic sites in Northern China, and the Indus Valley with the Harappan culture (6000 and 2500 B.C.E.) (Lawal et al., 2020; Tixier-Boichard et al., 2011; West and Zhou, 1988; Zeuner, 1963). Domestication has involved genetic changes in populations, like tameness, the ability to live in larger groups and to reproduce in captivity (Katajamaa and Jensen, 2020; Rutkauskaitė and Jensen, 2022). The modern broiler originates from Cornish, Leghorn, New Hampshire and Plymouth Rock poultry breeds, which were developed in the 19th century in Europe and North America (Jull, 1932; Laughlin, 2007).

Scientific advancements in genetics and trait development, breeding management and increased computing power to manage hugely complex datasets have enabled the development and implementation of balanced breeding in poultry over the last 60 years (Neeteson et al., 2023). Increasing complexity and long-term investments are required to implement and develop balanced breeding to serve the global needs in an ethical way. This has resulted in the development of poultry breeding from many specialized single line breeders to a lesser number with many lines and sometimes multiple species or types. Breeders have a responsibility to evaluate their role for global food security and sustainability and identify where breeding can have an impact. How a breeding program can make a difference for sustainability including welfare for different farm animal species (cattle, pigs, poultry, aquaculture) has been defined in a series of multistakeholder exercises, resulting in a Code of Good Practice for Sustainable Poultry Breeding and Reproduction, Code-EFABAR® (FAIP, 2005). The Code is routinely reviewed and updated to reflect current practices and societal expectations (EFFAB, 2023). The International Poultry Council (IPC) have identified where the poultry sector can make a difference looking at the UN Sustainable Development Goals (SDGs), and confirmed their commitment in an agreement with FAO (IPC, 2019). The role of a meat poultry breeding company is described in the Top 5 Commitments: 1) Health, Food Safety and Food Security; 2) Biodiversity; 3) Balanced Breeding Programme; 4) Importance of Management and Stockmanship; and 5) Transparency, Communication and Engagement (Aviagen, 2021a, 2022).

### Health, food safety and food security

Breeding programs situated on continents at both sides of the Atlantic Ocean ensure a safe supply in the short and longer term, as they serve as each other's backup in the case of global pandemic, natural disaster, bird illness, or other challenges in one area of the world.

The biosecurity program and protocols are a key cornerstone of the poultry breeding company. Breeding stock travels from the pedigree programs to the multiplication sites across the six continents, and from there to the poultry industry, enabling chickens to start of their production cycle in good health status. A global program of transport with high level shipping and monitoring conditions enables the transport of chicks and eggs across the world in a science-based way (Aviagen, 2021b, 2024; Elibol et al., 2023; EPB/ELPHA/USPEA, 2019; Özlu et al., 2022).

### Biodiversity

The major assets of a poultry breeding company are the within and between line diversity: the available diversity is the basis to select birds for future generations. By maintaining a large number of lines (e.g., over 50 for Aviagen and Hubbard; S. Avendaño, personal communication, Fig. 1) which vary widely for different traits such as growth rate, food efficiency, body composition and skin and feather colour, there is a broad variety of poultry resources to ensure sustainable global poultry supply now and in the future. Furthermore, populations which have not been selected since decades (1972 and 1996 respectively for Aviagen; Duggan, 2021), form a live repository of germoplasm that allows

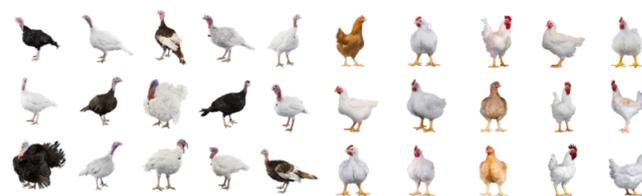


Fig. 1. Illustration of the genetic diversity in the lines managed by Aviagen's turkey and broiler breeding programs (Duggan et al., 2023).

comparing current and past genetics.

With a few breeding companies left, and some crossbreeds having large global market shares, "the effects of selection on commercial poultry genetic diversity have been a focus of debate and concern. Muir confirmed via comparative DNA analysis that the decrease in genetic diversity in chickens happened centuries ago, mainly as a result of breed formation, which inevitably results in some inbreeding. Commercial chicken breeding has caused less than one-eighth of diversity reduction" (Muir et al., 2008; Neeteson-van Nieuwenhoven et al., 2013).

Maintenance of diversity within populations is also important; commercial breeding programs maintain effective population sizes to achieve inbreeding rates below 1 % per generation in line with the FAO inbreeding guidelines (DEFRA, 2010; FAO, 2013; Neeteson-van Nieuwenhoven et al., 2013).

The widely available diversity forms the basis for the different crossbreeds in the market, satisfying the various needs of producers (Duggan, 2021), and consumers alike (Greib, 2008).

### The roles of balanced breeding, and management and stockmanship

Chicken breeding has developed from primarily looking at production traits (e.g., live weight and egg production) in the mid-20th century to balanced breeding including biological efficiency, environmental adaptability, health and welfare.

Production and welfare or reproduction traits can be antagonistic in nature: if selection is for the one trait only, the other correlated but unselected trait, likely moves in an undesirable direction. Overcoming trait antagonism is the basis, and condition, for successful balanced breeding. Hill et al. (2016) have shown how antagonistic traits can be improved simultaneously in the desired direction even if a (large) number of traits, including antagonistic ones, are included in the breeding goal, and balanced selection is applied across trait groups (Fig. 2; Avendaño et al., 2017).

### Broilers

Neeteson et al. (2023), Duggan et al. (2023) illustrate the improvements in a range of welfare traits like (long bone deformities (e.g., valgus/varus and tibial dyschondroplasia), toe defects, gait, contact dermatitis (e.g., footpad dermatitis, hock burn), skin lesions, cardiovascular function (ascites, sudden death syndrome) and livability over several decades in addition to improvements in environmental sustainability for the different crossbreeds in the portfolio offering. The main selection priorities of meat chickens are balanced across biological efficiency (e.g., growth rate, feed conversion rate, reproductive fitness, meat yield and quality), environmental adaptability, health and welfare leading to improved livability (Fig. 3). The Ross 308, for instance, has over one third of the emphasis on welfare traits like leg health, gait, cardiovascular strength.

Footpad health is an example of an important welfare trait. Originally it was only measured in pedigree birds. These are living in a bio-secure environment to ensure healthy breeding stock to pass on to the field. After footpad health issues were noticed in commercial flocks over twenty years ago, it was found that families ranked differently in the bio-

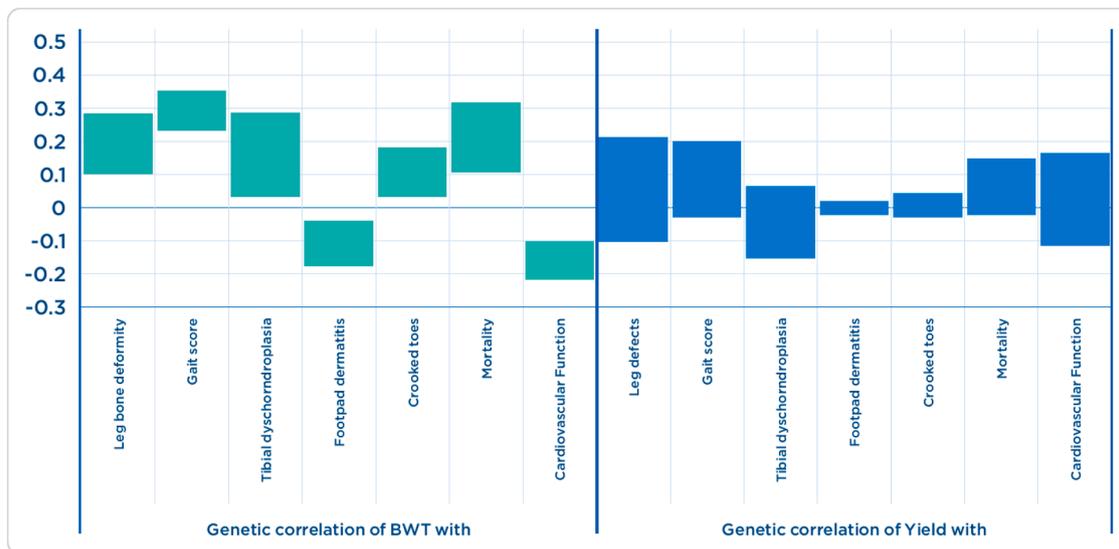


Fig. 2. Broiler Breeder Program ranges of Genetic Correlations between Live Bodyweight (BWT) and Brest Yield (Yield%) with Leg Bone Deformities (%), Gait Score, Tibial Dyschondroplasia (%), Footpad Dermatitis (%), Crooked Toes (%), Mortality (%), and Cardiovascular function as measured by blood oxygen saturation (%) (Avendaño et al., 2017).....

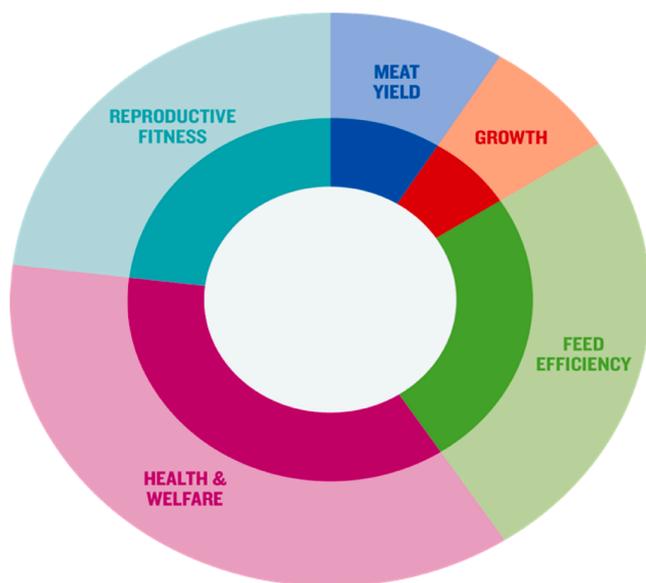


Fig. 3. Illustration of the selection focus of the Ross 308.

secure and commercial environment for footpad health. This is the so called genetics x environment interaction. Kapell et al. (2012) showed that a breeding goal accounting for the footpad health incidence in contrasting environments, a bio-secure environment, and a commercial environment with greater incidence allows accounting for the genetics by environmental interaction. It is an effective strategy to achieve improvements in footpad health in the field. In practice this means allowing only families with below average genetic predisposition in both environments to be selected. In addition to the breeding efforts, which takes 4-5 years to reach the commercial broiler level, management solutions to assist farmers to manage foot pad health will contribute to reduce the overall field incidence (De Jong and Van Harn, 2012).

As with footpad health, the measurements of pedigree birds in a clean environment and their brothers and sisters in a commercial environment (e.g., more exposure to pathogens, hot temperatures) is an excellent tool to improve the robustness of families, as only families doing well in both environments will be come parents of the next

generation. This leads to more robust birds across disease and climate situations. In addition, ss it is important that birds do not only thrive in moderate climates, then the breeding data from relatives in a hot environment contribute to families thriving in those climates. Furthermore, management guidance of farming in hot environments will provide farmers with additional information to manage birds in hot climates.

A number of breast myopathies (white stripping, wooden breast and spaghetti breast) have been reported in the last decade and have been linked to the selection for growth rate and breast yield. As explained with leg health, a reduction in the genetic propensity to express breast myopathies can be achieved by combining growth and breast yield with myopathies data through balanced breeding as illustrated in Bailey et al. (2015). Next to this, extensive research into “understanding the biological needs of the muscle and ongoing physiology in the modern broiler provides key time-points for strategies to reduce the myopathies and gain more insight into their aetiology (Bailey, 2023)”, as outlined for farmers and processors in the Broiler Myopathies Handbook (Aviagen, 2023).

Broiler Breeders

Factors included in the selection for breeder performance are amongst others liveability, footpad health, feathering, age at first egg, hen housed production, rate of lay, persistency of lay, cumulative hatchability and fertility and their corresponding persistency, egg weight and quality, egg storage ability, chick quality. Balanced breeding improves all of these traits gradually, generation by generation.

A complicating factor with breeder traits is that they can only be measured on the adult animal and some traits become available at the end of the production life. Selection of pedigree candidates takes place at an earlier phase hence when no own performance is available and only family performance is available. In this case genomics information adds significant extra accuracy to the prediction of breeding values by allowing the differentiation of candidates with the same sire and dam which is also called the prediction of the ‘mendelian sampling term’ (i.e., the bird’s unique sample of genes inherited from its parents). Similarly, for sex-limited traits, e.g., males who will not express female reproductive traits, the genetic merit for egg production can be more accurately predicted from combining their genomics profile with data from females in their family (e.g., mother, grandmother, sisters, cousins). With the same number of pedigree birds and the advantages described,

genomics information has allowed significant improvements at the reproduction level, at a faster rate than would have been possible with only quantitative information.

Feed intake management of broiler breeders during puberty has often been raised as a welfare concern. Broilers are selected for better Feed Conversion Rate (FCR), growth potential and meat production. Broiler breeders, with the same growth potential, do not need to grow as much; increasing mature weight is not desirable when considering the reproductive capability of breeders. On the other hand, breeders must have body fat, and grow or stay equal in weight during their reproductive life. Due to the very high correlations between early and late growth and appetite (Hill et al., 2016) it is not feasible to increase growth potential in the broiler but modulate the growth potential in the breeder.

Management changes, e.g., dietary composition and feed intake control during puberty, are another practical and effective approach to manage the broiler-breeder growth antagonism. The European Food Safety Authority (EFSA) (2009) indicated that “research in this area is very limited and more research is necessary to draw firm conclusions about feeding programs in relation to bird welfare”. Since then, research on alternative feeding systems and their impact on feeding amounts, behavior and stress indicators have shown management solutions resulting in stepwise improvements toward desired health, productivity, and behavior of broiler breeders. Adjusting dietary compositions results in relatively more energy and less protein to support the breeder in developing sufficient body fat. Applying a specific growth curve during rear, using mash-type diets, and environmental enrichments enhances balanced growth and desirable behaviors. Diluted diets result in improved feathering, higher livability, better litter quality, and longer feeding times (Van Emous et al., 2014; Van Emous, 2015, 2023). Van Emous (2024) showed that feeding pullets twice a day with diluting diets up to 30 % resulted in “improved behavior and welfare expressed in decreased stereotypic pecking behavior, and lower eagerness to approach the novel feeder with lower feed intake, with improved body weight uniformity and decreased mortality”. These treatments were neutral to production performance. Breeder management research is an ongoing and promising area allowing both improved welfare outcomes while allowing the expression of the reproductive genetic potential of the modern broiler breeder.

### Transparency, communication and engagement

Breeding companies operate at the start of the food production chain. As their achievements are permanent (present in the genes of populations), cumulative (the one improvement is added on to the previous one), and disseminated widely (chicken breeding material is spread across the globe), there is a responsibility to engage with society. It takes four years from the pedigree to the broiler phase, so improvements made in pedigree take that long to be seen in the broiler farming practice (Fig. 4).

Transparency and communication are important tools, e.g., explaining breeding and breeding achievements in peer reviewed journals, poultry magazines, web sites, new media. Cooperation with customers and representative associations is important to engage as responsible partners in the food chain. With meat poultry breeding being at the start of the food chain, and poultry meat being the most consumed land-based farm animal protein source, poultry breeding has a role to play in current and future global food security. High level biosecurity and transport, breeding and multiplication programs located in different places across the world, along with a diverse repository of meat poultry lines are instrumental bases for ensuring the availability of poultry breeding stock even in presence of unforeseen challenges. The requirements from society and markets for safe, healthy chicken meat produced with ever better welfare and a lower environmental impact can be met by a continuous improvement of all of these characteristics through balanced breeding: continuous improvement of the current

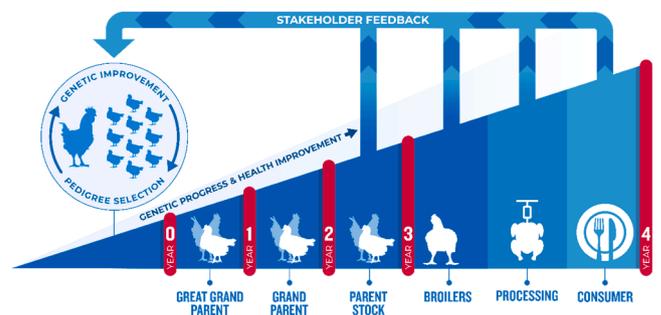


Fig. 4. Pedigree program, multiplication pyramid and feedback mechanism for a breeding company.

breeding traits and programs, and further broadening the breeding goal with new science and data-based innovations including new areas such as immune response and gut health. Development of up-to-date management information is important as the bird populations change on an ongoing basis, and the way to manage them will change gradually over time, as will the conditions poultry farmers will encounter due to technological and societal changes. It is also instrumental to understand how various breed options work across various production systems, as at the flock level, management is the largest contributor to the health, welfare and performance. This became clear in the Greenwell project (De Jong and Te Beest, 2020; De Jong et al., 2022) covering the fast and slow-growing breeds used in the Netherlands. Management was the key factor explaining the differences between the ‘Conventional’ system (fast-growing birds, standard conditions), ‘Kip van Morgen’ (medium growing broilers, farming conditions close to Better Chicken Commitment) and ‘Beter Leven 1 star’ (slower growing bird, additional management requirements like lower stocking density, environmental enrichment, early feeding of day-old chicks), when animal-based welfare outcomes were compared. This confirms the importance of robust animal and outcome-based welfare measures (IPWA, 2023). Breeding outcomes are long-term, cumulative – the gradual improvements add up –, and disseminated widely throughout the production chain. Understanding what future directions are foreseen in the medium and long term is the basis for change. Dialogue and close cooperation with stakeholders in society is crucial to anticipate that developments will fulfil new requirements. The route to achieve this in poultry breeding is steady and careful balanced selection leading to better welfare, productivity and sustainability outcomes.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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