CODE EFABAR
the commitment to responsible breeding

Species Specific Examples for implementation of Code-EFABAR®

Code EFABAR 2014/2016

Update Committee 2013

A. AQUACULTURE
Examples for implementation

INTRODUCTION

Impact and structure of breeding in EU aquaculture industry:

Fish breeding is a relatively recent activity in Europe when compared with other livestock productions. Several stages of development of breeding programmes are underway depending on species, volume of production, country and the know-how acquired in reproduction and zootechnics. The genetic improvement of farmed fish has developed rapidly since the mid-1980s, and nowadays, over 70% of EU fish production (especially salmon, rainbow trout, turbot and in a less extent halibut, sea bass and sea bream) is from selected stocks using methods of selection validated by the scientific community based on optimized mass selection or family based selection.
Investments since the mid 1980s led to the initiation of the domestication and selection of Atlantic salmon, rainbow trout, charrs, sea bass, sea bream, halibut and African catfish. Trials on other aquatic species, e.g. solea, common carp, tench, cod, European catfish, red porgy, and drums are underway. Where the main farmed species are concerned, European breeders are world leaders. They provide fertilised egg and fry to countries outside the EU, including Turkey (trout, bass and bream), Iran (trout), Chile (salmon and trout) and China (turbot).
Fish, from the breeder's perspective, produce large –indeed enormous- number of eggs at a single spawning (from several thousands to millions). They are, or can be, reproduced through artificial fertilisation for the most important species except for some new farmed species. As a result, for the species produced industrially (salmon, turbot, trout, bass and bream) the fish breeding sector tends to be evolving towards a small number of breeding companies per species that use up-to-date methods of evaluation. For most of these companies, breeding is only one part of their activity since they are also involved in growing, slaughtering and processing For most of the other species (charr, carp, catfish, etc.) the situation is different, where a large number of companies are involved in simpler breeding programs based on mass selection.

Breeding goals:

- Consumption of fish is advocated to improve human health and prevent cardiac diseases with its higher level of ω3 fatty acids. But fish are more costly than most of the other livestock products. As in other animal production systems, reduced production time through faster growth rate will reduce the cost of production, improve feed efficiency, limit risks of diseases and finally broaden human health benefits. Genetic improvement of growth rate is therefore a common breeding goal in all fish breeding programs.
- Improvement of feed efficiency is an important goal for sustainable aquaculture. It allows decreasing the pressure on feed grade fisheries, limiting the discharge of phosphorus and nitrogen in the water per kg of fish produced and finally decreasing the cost of the product. Currently, breeders are not able to measure this trait on the large scale needed for genetic selection, but indirect improvement of feed efficiency can be achieved by the decrease of the energetic cost of maintenance for non-productive traits (swimming, osmoregulation, reproduction), by selection on growth, or by delaying sexual maturation through selection, monosexing or triploidisation techniques.
- External body morphology and skin color are factors that are linked to the appearance of wild type animals by the consumers. A reduction of loss of the edible portion due to fat deposits (abdominal, back or ventral fat) is important to give a higher rate of fillet, a lower cost of product and improved quality. Texture and taste of the flesh depend mainly on its lipid content. In salmonids, color, luminescence, brightness and chroma of the flesh are considered important factors of fillet quality by consumers. Fillet yield is not an easy trait to measure but yield at gutting can be improved, especially in species with high levels of abdominal fat. An important heterogeneity in fillet yield exists between individuals, and

muscle lipid content or flesh pigmentation has a genetic basis. Most breeders have included selection on quality traits to improve the yield at processing and/or flesh quality (external conformation, % gutted, % lipids, and pigmentation intensity). Depending on species, a reduction of the percentage of fish reaching sexual maturation before harvest size has also been introduced, to avoid the negative effects of reproduction on flesh quality (% lipids, pigmentation), growth and survival. The same result can also been achieved faster by the production of monosex or sterile populations (see below). Such technologies are currently mostly used for the production of rainbow trout, brown trout and chars.

- Like all live animals and plants, farmed fish can also suffer diseases. As aquaculture is practised in open aquatic environments, and farmed fish are therefore in direct contact with potential pathogens. When diseases occur, dissemination of pathogens or use of chemicals and antibiotics to prevent diseases may also affect wild populations. Limitation of the effect of diseases by sanitary practices (disinfection, vaccination, physical treatment of water) is a classical approach. Resistance to diseases (e.g. furunculosis, infectious pancreatic necrosis) has some genetic basis. Selection to improve survival to diseases and hence animal welfare and limit the use of antibiotics has been introduced in most breeding programs. Collection of data on offspring in farming or in controlled conditions are performed on a limited number of individuals by BO (progeny testing or challenge test) to improve the performance of survival and welfare of all the individuals grown in the fish farms.
- As aquaculture is practised in open environments, unforeseen damage of production facilities due to meteorological conditions (e.g., storms) or accidents can occur, and domesticated individuals can escape and possibly reproduce with wild ones, which may have potential impacts on the fitness and biodiversity of the wild populations. Avoiding genetic interactions between escapees and wild populations is one of the major challenges for protecting biodiversity. Application of good practices is of utmost importance to limit the risk of escapement. As in plants (orange, lemon, potato, strawberry, kiwi, etc), polyploid stocks can be produced, and triploid fish (with 3 sets of chromosomes) are sterile. Genetic sterilization by triploidisation of the genome is not considered as a genetic manipulation by the EU, as it is also observed sporadically in wild populations (Directive 90/220/CEE). Moreover, it is advocated by international organisations and agencies (FAO, International Council of the Exploitation of the Sea, North Atlantic Salmon Conservation Organisation) to limit genetic interaction of escapees with wild populations, and National body authorities (UK Environment Agency) to prevent reproduction of domesticated fish put in rivers for restocking, even if only 99 to 99,5 % of triploidy can be achieved at production scale.

The Code-EFABAR® covers the breeding of all species farmed in the EU, except those that are not reproduced in the hatchery (eel, tuna, and yellow tail).

Breeding and reproduction traits and elaboration

PART I SUSTAINABILITY

A. Product quality

Trait	Breeding goal	Explanation
Body conformation	Improvement of the body conformation	BO can select on external body morphology to improve the morphology of the whole fish
Skin colour	Improvement of the external colour	BO can select on skin colour to improve the external appearance of the fish.
Flesh quality and lipid content of the fillet	Improvement of the flesh texture	Depending on species, an increase or a decrease of the fat level of the flesh can be introduced in breeding programs. BO can avoid sexual maturation by

		selection, or by use of reproduction techniques (monosexing, triploidy) can also limit the decrease of fat content in the muscle during the reproductive season.
Flesh quality and colour of the fillet	Improvement of the colour of the fillet	BO can improve flesh pigmentation by selection on this trait and/or by preventing the negative effects of sexual maturation during the reproductive season by use of reproduction techniques (monosexing, triploidy)

B. Genetic diversity

Trait	**Breeding goal**	**Explanation**
Genetic resources	Management of the genetic resources	Genetic diversity is necessary to maintain potential for genetic adaptation in the future. BO may have "in situ" and/or "ex situ" conservation plans through : • participation in national programs of conservation, • maintenance of non-improved live broodstocks, • maintenance of cryopreserved lines of semen.
Genetic variability	Conservation of genetic variability in selected lines	BO will actively limit inbreeding per generation within purebred lines or by the development of different lines that can be crossed to produce juveniles for the growers.
Genetic security	Have plans to secure the genetic material in case of accidental situations	BO will have security systems (back-up populations, cryopreserved semen) that will protect the genetic material if accident occurs (e.g. disease outbreak).

C. Efficiency

Trait	**Breeding goal**	**Explanation**
Growth rate	Decrease the duration of the growth period.	BO can select for fish growth to decrease cost of production and improve domestication.
Feed efficiency	Improvement of feed efficiency	BO can improve indirectly feed efficiency by selection on growth and/or by the prevention of the sexual maturation by selection or by use of reproduction technologies (monosexing, triploidy).
Yield at processing	Improvement of the edible part of the fish	BO can select to limit the development of abdominal fat tissue and to improve fillet yield.

D. Environment

Trait	**Breeding goal**	**Explanation**
Feed efficiency	Decrease water pollution/kg fish produced	BO can improve indirectly the feed efficiency by selection on growth or by

		the prevention of negative effects of reproduction by selection to delay maturation or by use of reproduction technologies (monosexing, triploidy). BO can improve the industry's sustainability by selecting for increased tolerance to and utilisation of plant-based feed.
Sterility	Reduce the potential impact of escapees	BO can use reproduction technologies (monosexing, triploidy, hybridization) to produce sterile populations to avoid genetic interaction with wild conspecifics and to protect wild populations.
Genetic resistance to diseases	Reduced need for use of medicines or chemicals	Selection to increase genetic resistance can help to limit negative effect of diseases or their treatments on wild populations and nature in general. BO can select to improve disease resistance.

E. Welfare and health

Welfare

Trait	Breeding goal	Explanation
Genetic defects	Decrease the incidence of genetic defects	The BO can select against genetic defects in fish (external or internal malformations or abnormalities of functional organs such as bony tissues, organs, heart, gills, opercula).
Age at sexual maturation	Limit mortality	The BO can reduce the negative impact of sexual maturation on fish survival by selection on delaying the age of sexual maturation past the harvest size or by use of reproduction techniques (monosexing, triploidy)
Disease resistance	Limit mortality and disease	The BO can improve disease resistance by selection for high survival and favourable gen markers
Balanced breeding	Balance in production, reproduction, health and welfare	The BO can evaluate a set of traits to select robust and adapted animals
Domestication	Animals better adapted to farming conditions	Normally associated with selection for growth

Animal health

Trait	Breeding goal	Explanation
Disease resistance	Improvement of survival	BO can reduce fish mortality due to diseases by selection on specific disease resistance
Robust fish	Improvement of robustness of fish	BO can improve the robustness of fish by manipulating environmental conditions before selection for growth and survival
Sanitary status	Diffusion of genetic products that are free of the main diseases	As selected brood stocks are at the top of the food chain, the site of selection

		must be "officially free" of the pathogens recognized as the most important by EU Directive (24 October 2006) and recorded in Part II Listed diseases.
Farming environment	Improvement of animal health	BO shall optimize the conditions under which breeding animals are kept and use the latest scientific knowledge and field experience to create beneficial conditions in terms of • sanitary status • stocking density • balanced nutrition • environmental conditions

Human health

Trait	Breeding goal	Explanation
Healthy food	Ensuring public health	BO shall seek to ensure the best protection of public health and the application of EU regulations to provide healthy food for the consumers.

PART II TECHNOLOGY

A. Breeding

Trait	Explanation
Genealogy	BO can use either DNA fingerprinting or physical tags like RFID tags or fin clipping to assign candidates to their parents using small pieces of tissues (fin, blood, etc.) that can be regenerated by candidates.
Challenge test or progeny testing	BO can use challenge test or progeny testing to select on disease resistance or for better adaptation to environmental farming conditions. BO can use challenge test or progeny testing on a limited amount of candidates only when this can be in favour of welfare for the millions of farmed fish over time.
Marker-assisted and genomic selection	DNA information could be used as additional information in the selection process. This could prove helpful for improving "difficult" traits by selection, like sib-evaluated (invasive) traits, traits with low heritability and traits which are difficult or expensive to measure.
Transgenics	BO currently do not use transgenic techniques

B. Reproduction

Trait	Explanation
Artificial fertilisation	External fertilisation is one of the ways to reproduce fish in aquaculture for some species while for others it is impossible to practise. This technology prevents disease transmission and will be used preferentially for breeding when it will be biologically and economically feasible.
Cloning	BO currently do not use of cloning
Collection of semen and preparation	BO can use specific extenders to allow for a longer duration of sperm motility in order to maximize success of fertilization and to decrease the risk of loss of genetic variability.
Freezing of semen	BO can use frozen semen for preservation of genetic variation, security aspects as well as optimal utilization of the best males across year-classes
Embryo transport	Distribution of genetic material to the farmer. The normal method of

	distributing the genetic material is as a fertilized egg in a specific robust phase (Salmonids). This phase allows disinfection of the eggs to prevent the spread of disease.
Synchronizing of ovulation of eggs and spermiation stimulation	BO can use a small active peptide GnRH (authorised by EU regulation), given to the parental fish to stimulate the final sexual maturation and releasing of the gametes so that top quality gametes are optimally fertilised
Monosexing	Farming of immature animals is of prime interest to avoid the deterioration of flesh quality with the occurrence of sexual maturation before reaching the harvest size. Phenotypic sex of the breeders can be managed during the period of sexual differentiation (mostly embryonic or larval stage) by manipulation of environmental parameters such as temperature (sea bass, tilapia), social dominance (hermaphrodite species like sea bream) or by hormonal treatment (salmonids, cyprindids, etc). This allows the production of juveniles of the desired sex at fertilization. The result is the same with that achieved in livestock production with semen sexing excepted that the control is made at the breeder level in fish and not at the sperm level. Hormonal treatment to sex reverse breeders is recognized by the EU regulation (Directive 96/22/CE) and is used to produce monosex fry, in most cases female, without any treatment on the fish eaten by the consumer. BO can use monosexing only where no harm or compromise of welfare is introduced as a result of this technology.
Triploidisation	Triploid fish are sterile and are not considered as GMOs by EU regulations (Directive 90/220/CEE). This sterility has great interest for improving several traits (survival, feed efficiency, flesh quality) when harvest occurs after the reproductive season. BO can use triploidisation only when this will not compromise fish welfare

2. CATTLE

Examples for implementation

INTRODUCTION

Impact and structure of breeding on cattle industry in EU

Cattle Breeding Organisations must follow the relevant rules in their countries.

Breeding Organisations (BO) are in most cases small and medium size enterprises (SME) and often organized as co-operatives. The overwhelming use of AI in the dairy industry has made the obtained genetic progress rapid for traits under selection. The massive use of frozen semen facilitates the transportation and business across national borders. The BO have many domestic customers and in several cases a complementary sale also through distributors in other countries. Differences in breeding objectives are to some degree a way to create a distinctive image of the company. The market for the farmers is huge, due to the availability of genetic material of different origin.

In the cattle breeding industry the competition between different companies is fierce. In every country and at many farms semen from different sources can be found. The market is international and the costumers need to compare information from several different countries. Because of this it is important that the estimation of international breeding value is as complete as possible and is covering all important traits. During the last years a comparison of genetic material from several countries has been possible through INTERBULL's international breeding value estimates. In a near future also international comparison of GEBV will be available through INTERBULL. The number of traits with estimated international breeding values is increasing and comprise in September 2013 of milk production, conformation, direct longevity, calving traits, workability and udder health.

Breeding and reproduction traits and elaboration

PART 1 SUSTAINABILITY

A. Production traits and product quality traits

Element	Breeding goal	Explanation
Milk carrier production	Maintained or decreased	
Milk fat production	Increased milk fat production	
Milk protein production	Increased milk protein production	
Growth rate Dairy cattle Beef cattle	 Maintained growth rate Increased growth rate	Growth rate is a trait under selection within the beef breeds. In general growth rate is not considered in dairy breeds.
Somatic cell count (SCC)	Decreased number of somatic cells in the milk	SCC is an indicator of poor udder health. In several countries milk prices are depending on SCC.
Processing quality, milk	Maintained or improved processing quality to meet market requirements.	Increased quality and yield of processed consumers' products.
Carcass and meat quality Dairy cattle Beef cattle	 Maintained Improved	In beef cattle carcass and meat quality are traits under selection in several countries. The development is driven by demands from the processing industry.

To which extent selection is conducted for increased milk, fat or protein production is a BO decision. In the long run milk composition will be determined by the dairies payment profiles. When processing quality is depending on the effect of different protein genotypes these will be provided in a market-driven situation.
Genotypes of muscle hypertrophy (MH) in cattle are to some degree known and have been used in selection programmes even though MH is linked to underdevelopment of internal organ.

Participation in INTERBULL evaluation for milk production and SCC will provide comparable proofs across-countries.
The initial steps for an international evaluation of growth traits in beef breeds, Interbeef, have started. These activities will most likely develop into several trait groups and breeds.

B. Genetic diversity

Element	Breeding goal	Explanation
Genetic diversity	Maintained genetic diversity within commercial breeds. Conservation of local breeds.	A high genetic diversity is essential to maintain sustainable breeding in the future for all commercial breeds. A special situation is when a local product is requiring a certain breed; as in the case of the Fontina Cheese in Italy that only process milk from the Valdostana Breed. Preservation of local and endangered breeds is a (global) society issue. BO can take part in this conservation through cryo preservation of semen and/or embryos in gene banks.
Inbreeding	Rate of inbreeding balanced with rate of genetic change.	BO will only allow a maximum of 1% of increased inbreeding per generation in their nucleus programmes as is advised by FAO.
Cross breeding		Exploitation of hybrid vigour in commercial herds is done to a large extent in beef cattle production. A growing interest of cross breeding can also be noticed in dairy cattle.

For large international breeds out cross pedigrees will have a larger commercial potential and will therefore be sought after.

C. Efficiency

Element	Breeding goal	Explanation
Fertility Female Male	Maintained or improved male and female fertility.	Reproductive soundness is a prerequisite for both dairy and beef production and female infertility is one of the major causes for involuntary culling. In grazing based production systems it is essential to have an

		annual calving.
Feed efficiency	Improvement of the efficiency of utilized feed resources.	A better utilisation of resources is preferable. In general the increased productivity that is generated by the present breeding programs has improved the feed efficiency. However, ruminants are often using local feed resources under none optimum conditions.
Productive life	Improvement of longevity of cows.	BO want to select for robust animals that will cope with numerous environmental conditions, which increase the longevity of the cows.

Participation in INTERBULL evaluation for direct longevity, mastitis resistance, SCC and female fertility provides directly or indirectly comparable proofs cross countries for productive life.

D. Environment

Element	Goal	Explanation
Nitrogen and Phosphate emissions	Reduced N and P emissions per - Kg of beef produced - Kg of milk produced	An improved feed efficiency decrease the amount of manure produced (N and P emission) per kg of beef and milk.
Greenhouse gas emissions	Reduced greenhouse gas emissions - Kg of beef produced - Kg of milk produced	An improved feed efficiency decrease the amount of greenhouse gas emissions produced per kg of beef and milk.

National and international efforts are made to explore different methods for recording feed efficiency, feed intake and greenhouse gas emissions.

E. Animal Welfare and Health

Element	Breeding goal	Explanation
Genetic defects	Decrease the presence of genetic defects.	The BO will select against genetic defects in animals. Young bulls will be tested against known/suspect defects such as BLAD, MF and CVM.
Mastitis incidence	Decrease the incidence of mastitis.	Udder health problem is a welfare as well as a production problem and mastitis is one of the major causes for involuntary culling of dairy cattle.
Disease resistance against other diseases than mastitis	Decreased frequency of animals with other diseases than mastitis.	Other diseases than mastitis are also causing involuntary culling in cattle.
Udder conformation	Maintained or improved udder attachment, udder depth and teat traits.	Functional udder conformation is a trait that improves longevity and udder health.
Leg problems	Decreased cull rate due to feet and leg problems	Leg problems are an important source for culling of cattle.
Locomotion	Improved locomotion and	Locomotion is a trait that is

	natural movements.	recorded in several countries. It has an impact on longevity. Locomotion is also an indicator of hoof disorders.
Hoof health	Decrease the incidence of hoof health problems	Hoof disorders are traits that are recorded in some countries and more countries have shown interest in the traits. Hoof health problems have an impact on longevity and the wellbeing of animal.
Calving ease	Maintained or decreased frequency of difficult calving	Calving ease should be regarded as both a sire and a maternal grandsire trait. It is also recommended to separate calving results between virgin heifers and older cows. A difficult calving increases the risk for calf mortality and a poor start of the lactation for the dam. For breeds with a low frequency of difficult calving the aim is to maintain that status and for breeds with a higher frequency the aim is to decrease the frequency. Caesarean section shall under no circumstances be accepted as the normal procedure neither for commercial cows nor for breeding stock.
Calf survival	Maintained or improved calf survival.	The same arguments can be applied on calving survival as on calving ease.
Milkability	Optimum milk flow	Milkability is an optimum trait where extreme individual are exposed for more udder health problems.
Temperament	Calm and manageable cattle	Bad tempered individuals are a risk for the animal itself as well as the farmers.
Polledness		In several production systems dehorning is the normal procedure, under these conditions polledness can be preferable.

Participation in INTERBULL evaluation for feet and legs, udder conformation, udder health, calving traits, milkability and temperament will provide comparable proofs across countries and gives a tool for farmers to select against impaired animal welfare and health.

PART II TECHNOLOGIES

A. Breeding technologies

Breeding technologies shall always be judged by its contribution to the breeding objectives.

Element	Explanation
Marker and gene assisted selection, genomic evaluations	BO may use marker or gene assisted selection. These techniques are expected to enhance genetic improvement for quality, welfare and health traits. The use of breeding values estimated by genomics will bring a better accuracy on known traits and/or evaluation of new characteristics. The introduction of genomic selection in major breeding programs has increased the use of non-daughter proven bulls in general and especially as sires of sons.
Transgenic	BO currently do not make use of transgenic techniques

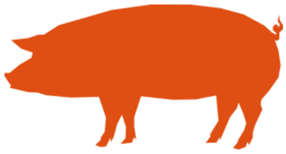
B. Reproduction Technologies

Reproductive technologies shall always be judged by its contribution to the breeding objectives.

Element	Explanation
Artificial Insemination (AI)	AI is the recommended reproductive technology for sires. AI makes it possible to detect genetically superior bulls by progeny testing. Proven bulls make it possible to achieve the desirable breeding goals. AI will facilitate extensive use and trade with genetically superior bulls. AI is a recommended method to prevent disease transmission.
Semen technologies	Freezing of semen is a normal procedure in the AI industry. Semen sexing is a method to avoid unwanted animals to be born. BO and cattle farmers will use sexed semen when it is a suitable method for achieving desirable goals. Frozen semen is a cheap method for generating a long lasting gene bank.
Collection of semen and preparation	Collection of semen from bulls is done by trained personnel and with adequate equipment to ensure health and welfare of the bulls. The semen doses shall have a sufficient quality and quantity of cells to provide a normal pregnancy rate. Furthermore an accurate identity and no transmission of diseases must be achieved. Under no situation is electro ejaculation a method that can be accepted.
Oestrus induction	Oestrus induction is a management method and BO do not influence its use.
Embryo transfer (ET)	Embryo Transfer is an accepted reproductive method for genetic superior females, bull dams. Super ovulation and subsequent collection of embryos makes it possible to obtain more offspring after superior females.
Embryo technologies	Frozen embryos facilitate trade with embryos at a low health risks. ET with frozen embryos is a method to introduce new breeds in a country. Frozen embryos are a cheap method for generating a long lasting gene bank. Embryo sexing is a method to avoid unwanted animals to be borne. In vitro production of embryo is an alternative embryo production method. BO will use the embryo techniques that cause no harm or suffering to the animal.
Cloning	BO currently do not make use of cloning.

3. PIGS

Examples for implementation



INTRODUCTION

In pigs, during the twentieth century there has been a move from pure breeding to crossbreeding. This creates heterosis (hybrid vigour) and allows different selection strategies to be applied to male and female lines. Pig breeders once focused on traits with high heritability, such as overall growth and body leanness. Using computer technology, they have now turned their attention to more challenging traits with lower heritability, including litter size and survival traits. Genomic selection enables breeding organisations today to bring about improvements in traits that are difficult to deal with through the traditional methods, like disease resistance and pork quality.
At research level new technologies come available like for example creating fully functional sperm from embryonic stem cells and 'gene editing' which involves snipping the animal's DNA and correcting one of the basepairs, in effect changing a single one of the three billion 'letters' that make up its genome. New technologies like these have the potential to speed up the improvement of breeding stock considerably to meet the demands better.

Breeding and reproduction traits and elaboration

PART I SUSTAINABILITY

A. Product quality

Trait	Breeding goal	Explanation
Carcass quality	Improvement of carcass composition (lean to fat ratio) and its uniformity, up to defined optimum levels for a specific end product.	Market-driven production with regard to uniformity of carcasses (incl. cuts) are investigated and implemented in the breeding programme. Different products have different optimum leanness levels, and different crosses of breeds are used to achieve these. With regard to special breeds for special markets, other qualities are specifically defined by the BO.
Meat quality	Improvement of the quality of meat in terms of water holding capacity, colour, flavour etc.	Consumer demands about quality of meat are investigated and implemented in the breeding programme. Less drip loss, (uniform) meat colour and sufficient level of IMF for characteristic pork taste.
Boar taint	Improvement in lowering the % of tainted carcasses with entire male production	For animal welfare and efficiency reasons, castration is not desirable. However in entire males a certain proportion of animals has an off odour smell when their pork is heated. Genetic improvement can lower this percentage.

B. Genetic diversity

Trait	Breeding goal	Explanation
Genetic diversity	Maintenance of genetic diversity.	A high genetic diversity is necessary to maintain sustainable breeding in future. If breeds or lines lose their commercial value, BO will take care of 'in situ' conservation through cryopreservation of semen and/or embryos.
Inbreeding	Rate of inbreeding balanced with	BO will actively control the rate of

	rate of genetic change.	inbreeding within purebred lines, making use of management factors like mating schemes and optimal genetic contributions.

C. Efficiency

Trait	Breeding goal	Explanation
Energy/protein conversion efficiency	Improvement of the efficiency of the used energy and protein per kg pork	When pigs have an efficient use of energy and protein they will consume less feed for the same production level.. Entire males are more efficient than castrates.
Reproductive output	Increase of number of slaughter pigs per sow per year	BO will select for a balanced increased litter size, mothering ability of the sow, and healthy and vigorous piglets. This improves the efficiency by lowering the sow feed per kg of pork.

D. Environment

Trait	Breeding goal	Explanation
Nitrogen / Phosphorus emission	Reduce the nitrogen and phosphorus emission per kg of pork meat	Improvement of energy and protein conversion efficiencies (section C) reduces N and P emission, and reduces manure production.

E. Welfare and health

Welfare

Trait	Breeding goal	Explanation
Stress	Elimination of stress susceptibility.	Selection against stress susceptibility as caused by the halothane gene. Stress susceptible animals have to be kept in conditions that minimise the expression of their susceptibility; this is inefficient and sometimes unsuccessful. BO must find a balance here with selection for higher carcass leanness, which is relevant mainly in male lines in specific markets.
Congenital defects	Decrease of incidence of congenital defects with a genetic component	The BO will select against congenital defects with a genetic component (like Atresia Ani, Cryptorchidism, Splayleg, Herrmaphrodism and Hernia).
Leg problem	Decrease of the incidence of leg problems	The BO will select against leg weakness and lameness.

Animal health

Trait	Breeding goal	Explanation
Disease resistance	Improvement of general and specific disease resistance	Animals with a high disease resistance are less frequently ill and need less vaccinations and use of antibiotics.
Longevity of sow	Improvement of longevity of sows	Improved longevity of sows is related to a long lifetime production with minimal health problems.
Vigorous piglets	Improvement of the health and vigor of piglets	Piglets with higher vigorousness have a higher chance to stay alive and are less susceptible to diseases. This will reduce

		the need for veterinary treatment and use of antibiotics.
Survival of pigs	Improvement of overall survival of pigs from birth to slaughter	BO will select for improved survival rates throughout the pig's life. This will reduce the need for veterinary treatment.
Leg quality	Improvement of leg quality	Better leg quality leads to better animal health and welfare.
Teat number	Functional teats	A sow should have a sufficient number functional teats to feed a litter during lactation.
Maternal ability	Improvement of mothering ability	The best sows produce healthy and living piglets at weaning.
Robustness	Improvement of pig robustness towards a better adaptation to changes in production conditions.	Robust animals can cope with various environmental conditions. Improved robustness will also increase survival rates and the longevity of sows.

PART II TECHNOLOGY

A. Breeding

Trait	Explanation
Marker and gene assisted selection, genomic evaluations	BO may use marker or gene assisted selection. These techniques enhance genetic improvement especially for quality, welfare and health traits. The use of breeding values estimated by genomics will bring a better accuracy on known traits and/or evaluation of new characteristics.
Challenge tests	Challenge tests are used to select for better resistance to disease or against behavioural problems like tail biting. These relatively small scale tests are necessary to improve the health status and welfare of large populations.
Biopsy	BO may take a biopsy for fat sampling boars for evaluating boar taint components when local legislation permits to do so. Taking biopsies helps to genetically reduce boar taint in entire males.
Transgenic	BO do not make use of transgenic techniques.

B. Reproduction

Trait	Explanation
Artificial insemination (AI)	Artificial insemination is used to make genetic dissemination more effective and efficient, and to reduce disease transmission.
Collection of semen and preparation	Collection of semen from boars is done by trained personnel and with adequate equipment that ensures health and welfare of the boars. Good semen quality can only be achieved with healthy boars.
Freezing of semen	Freezing of semen is done to enable safe transport over long distances and to ensure the health status of the semen. Frozen semen can be stored for gene banking or for long distance transportation.
Oestrus induction	Oestrus induction is used to synchronise groups of sow in cases where a balanced reproduction pattern is required.
Embryo transfer	Super ovulation and subsequent collection of embryo transfer is used to to make genetic dissemination more effective and efficient, and to reduce disease transmission.
Embryo freezing	Freezing of embryos is done to enable safe transport over long distances and to ensure the health status (= reduction of disease transmission). Frozen embryos can be stored for gene banking or for long distance transportation. Embryos can be washed with antibiotics and with trypsine to make them free from pathogens

In vitro embryo production	In vitro production of embryo is an alternative embryo production method. BO will use in vitro embryo production only where no harm or compromise of welfare is introduced as a result of this technology.
Semen sexing	Semen sexing is a method to avoid unwanted animals to be born. BO will use sexing of semen only where no harm or compromise of welfare is introduced as a result of this technology.
Embryo sexing	Embryo sexing is a method to avoid unwanted animals to be born. BO will use sexing of embryos only where no harm or compromise of welfare is introduced as a result of this technology.
Embryo selection	Embryo selection is a method to avoid unwanted animals to be born. BO will use embryo selection only where no harm or compromise of welfare is introduced as a result of this technology.
Sperm cells from embryonic stem cells	Creating fully functional sperm from embryonic stem cells helps BO to speed up the improvement of breeding stock. BO will use this technology only where no harm or compromise of welfare is introduced as a result of this technology.
Cloning	BO currently does not make use of cloning.

4. POULTRY

Examples for implementation

INTRODUCTION

In poultry, the twentieth century saw a move from pure breeding to crossbreeding. This utilised hybrid vigour and allowed different selection emphases to be applied to male and female lines. Most table eggs today come from specialist crossbred layer chickens, and poultry meat is mainly produced from crossbred meat-type broilers, turkeys and ducks. Within the segment of crossbred lines, there ~~is~~ are a wide variety of lines that result in poultry with a variety of colours of the bird and/or the eggs or meat, , various growth rates of broiler lines , from slow growing lines to fast growing lines, various characteristics for growth rate, egg production and performance qualities. Other poultry species such as geese, guinea fowl, ostriches and pigeons serve niche markets.

During at least the last four to five decades, poultry breeding companies have steadily broadened their breeding goals and have worked towards improving various health, welfare and performance characteristics simultaneously. The science which underpins animal breeding (and associated technologies) has been used to identify avian and genetic line characteristics required for more robust selection strategies, Now, many welfare and sustainability traits, such as cardiovascular function, skeletal strength, feed efficiency, and liveability are included in breeding goals of genetic lines for crossbred poultry. Each poultry breeding company involved collects a large amount of data on a variety of traits for each bird including information on welfare, health, fitness, reproduction and production efficiency. The major achievement of this is that it is now possible, and common practice, to improve at the same time traits that are antagonistic, i.e., when you improve the one it is likely it will have a negative effect on the other trait. This is often the case with production and health or welfare traits. Nowadays, the breeding goal is being made more sustainable by including both types of traits and to select all in the desirable direction so that both traits will improve. This principle is then applied across the whole breeding goal of 30 to 40 traits, all of which are under selection simultaneously. The desired balance is maintained within specific biosecure breeding populations to optimize avian health, to limit in-breeding, and to achieve high selection intensities, proper statistical methodology, accurate data recording infrastructure and continuous improvement of accuracy of measurement of each characteristic within the breeding population for each genetic line.

Breeding companies maintain primary breeding lines to produce commercially available crossbred lines with various traditional and modern selection methodologies. Breeding companies also maintain various experimental or control lines, to evaluate the potential of new crossbred lines and to ensure they can supply future needs, while keeping the rate of inbreeding below 1% per annum (Hiemstra & Ten Napel, 2013). Muir et al (2008) indicated that the modern farming system has contributed less than 5% to the level of inbreeding, despite intense levels of selection, closed populations and industry consolidation since 1950. This indicates that poultry breeding companies maintain their genetic resources and pure line poultry flocks in a secure and sustainable manner. (Industrial breeding has caused less than 1/8 of this diversity reduction: most of it happened centuries ago, mainly as a result of *[Muir, W. M. et al]* breed formation which necessarily results in some inbreeding.

Europe is the main source of ownership of the world's poultry breeding stock. Continuing concentration has led to the current situation that only four groups of primary breeders account for about 90 % of the layers, broilers and turkeys produced annually. Most breeding companies are offering several different strain crosses to satisfy a range of customer demands. These breeding companies do not only sell genetically improved animals but also provide technical service to their customers and to the customers of their customers. In the definition of their breeding goals they take into account customer, policy, consumer and society developments and requirements. Alongside the use of Code-EFABAR® the poultry breeding companies are increasingly committed to transparency often publishing their breeding improvements in technical and peer reviewed articles. Thus, they are committed to the whole food supply chain.

Breeding and reproduction traits and elaboration

PART I SUSTAINABILITY

A. Product quality

Trait	Breeding goal	Explanation
Egg quality	Improvement of external and internal egg quality to meet specified market requirements	The main external criteria are average egg weight (high percentage in preferred grades: Medium and Large) and shell quality (strength, colour); the main internal criteria are composition (yolk/albumen ratio), firmness of albumen (Haugh Units) and freedom from inclusions (blood and meat spots). Yolk colour, determined by nutrition, is not under selection.
Meat quality	Improvement of "yield" and meat quality characteristics of meat-type poultry in terms of valuable parts, especially breast meat; selection against breast blisters and other defects to reduce condemnation rate	Genetic improvement is driven by demands of the processing industry for uniform high quality meat produced efficiently. Weight at slaughter and differences between white (breast) and dark (leg) meat are used to generate a wide range of products. New technologies are developed and applied to improve the measurement of meat characteristics and meat quality.
Carcass quality	Improvement of carcass composition and its uniformity, up to defined optimum levels for a specific end product.	Market-driven production with regard to carcass quality is investigated and implemented in the breeding programme. Different products have different optimum levels of e.g. breast meat, and different crosses of breeds are used to achieve these. With regard to special breeds for special markets, other qualities are specifically defined by the BO. New technologies are developed and applied to improve the processing quality and other characteristics.

B. Genetic diversity

Trait	Breeding goal	Explanation
Genetic variation	Conservation of local breeds Maintenance of genetic variation	Preserving local and endangered breeds is a (global) society issue and is organized through national and international collaboration. Breeders actively take part in this collaboration. Sustainable breeding generates

	within and between lines Maintenance of control lines	competitive rates of genetic improvement, whilst preserving genetic variation. A way to preserve genetic variation is to keep many lines with a wide range of growth rate, colour or other desired characteristics, with a sufficiently large population in secure location(s) to ensure they can supply foreseeable future demand. Next to the lines directly used for current crossbreeds, BO maintain a variety of developmental and research lines. BO may maintain control lines – lines which have not been selected since a certain point in time, e.g., 1972 or 1996.
Inbreeding	Rate of inbreeding balanced with rate of genetic change	The rate of inbreeding per generation within purebred lines is actively minimized and maintained below 1% (FAO recommendation), via use of management factors such as mating schemes and inbreeding control programmes.
Genetic security	Security flocks and/or double banking of breeding programmes	BOs will maintain geographical separation plus security flocks as back-ups in case of accident (e.g. disease outbreak). Breeding programmes located in different regions or continents to secure future supply.

C. Efficiency

Trait	**Breeding goal**	**Explanation**
Egg number	High egg output	Egg-type chickens and some meat type breeders are selected for higher numbers of saleable eggs/live chicks per laying cycle (egg income/number per hen housed).
Hatchability	Improved hatchability	Birds are selected to improve the fertility and hatchability of the eggs produced.
Growth rate	Reduction of age at market weight	Modern broiler meat-type poultry are selected for more efficient growth rate and feed conversion to reach desired market weight quicker This is not or much less the case in slow growing breeds

D. Environment

Trait	**Breeding goal**	**Explanation**
Feed efficiency	Reduced feed consumption per - kg egg mass in laying hens, - kg weight gain in meat-type poultry	Improved efficiency of feed utilisation decreases the overall impact of poultry meat and egg production on the environment Feed intake is measured individually and /or via measurement of individual feeding events in group circumstances

		and under competition between birds.
Water efficiency	Efficient water consumption	Balanced water consumption in relation to egg or meat production decreases the amount of water used per kg product, ensures drier bedding and improves the overall impact on the environment. Water intake can be measured individually and / or via measurement of individual feeding events in group circumstances and under competition.
Robustness	Strain crosses for a wider range of environmental conditions	The ability of animals to cope with given environmental conditions is important under animal welfare and economic considerations. Siblings or other family members of birds selected under more optimal environmental conditions are also tested under less optimal commercial conditions assessing gut health, digestive and immune function, liveability, growth and uniformity, as well as leg health. This helps ensure both freedom from specific diseases and development of robust birds in a range of environments.

E. Health and Welfare

Trait	Breeding goal	Explanation
Monofactorial genetic defects	Decrease frequency of defects	No animals with apparent defects are selected; if possible, identify carriers of recessive defects with DNA markers; selection on the basis of family information.
Leg strength	Improvement of leg strength and reduction of incidence of leg and toe problems	Animals are tested for visible and subclinical leg and toe integrity, posture and gait to ensure a strong support system for the individual and family (via e.g., pedigree and sibling testing).
Osteoporosis in laying hens	Reduction of incidence of broken bones	Osteoporosis may result from excessive depletion of bone minerals towards the end of the laying period; selection for stronger bones has been shown to be effective, but a negative correlation with shell strength exists.
Cardiovascular capacity and function	Reduction of incidence of "sudden death syndrome" and ascites in broilers and "round heart" in turkeys	Growing broilers and turkeys need sufficient oxygen (blood supply) and optimal temperature to avoid mortality due to ascites (broilers) and cardio-vascular problems (turkey); family selection for lower incidence requires exposure to critical conditions, but indirect measures are utilized such as oxygen saturation of blood
Cannibalism, feather pecking	Reduction of incidence of undesirable behaviour	Cannibalism & feather pecking are multi-factorial problems which depend on

		group size, light intensity and other environmental factors. Selection under group circumstances and family selection techniques are used to improve the adaptability of laying hens to floor systems Reduction of individual sensitivity to feather pecking is also used. Development of new technologies to detect animals pecking and being pecked, will improve group social behaviour. The causes for feather pecking and cannibalism may be different between chickens and other poultry species. For that reason, care must be taken in using results from the one species when extrapolated to another species.
Disease resistance	Improvement of resistance to specific diseases, reduced need for treatments	No prophylactic use of antibiotics in the pedigree populations. Freedom from egg transmitted diseases. Optimal general hygiene (all-in, all-out management) will be necessary for short-term results, but efforts to improve genetic resistance continue as a long-term strategy. Breeders are committed to control zoonoses through the testing and elimination of infected stock from their programmes.
Behaviour	The behaviour of the birds at various levels is being investigated to ensure the birds thrive well with reducing need for intervention treatments and to answer questions raised in society.	BO investigate behavioural performance at various poultry breeding levels and develop and implement traits accordingly, e.g., social group behaviour, nesting behaviour, reproductive behaviours, displacement behaviours such as feather pecking/cannibalism, aggression,, feeding and drinking behaviour, and other maintenance behaviours.
Gut health and bird physiology	Improving gut health and physiological strength of the birds	BO are developing technologies and traits to improve the gut health of the birds (see section under Environment/Robustness above)

Housing environment	Optimisation of conditions under which breeding animals are kept	Use latest scientific knowledge and field experience to create beneficial conditions in terms of • sanitary status • stocking density • balanced nutrition • water supply • house climate, litter quality • light source and intensity.
Healthy breeding stock	Production and multiplication of crossbreeds free of identified diseases, zoonoses and pathogens	Ensuring that a number of diseases (e.g. Newcastle disease, Avian influenza, Salmonella, Leucosis, Mycoplasma) do not enter the production chain via the

		BO.
Training and stockmanship	Training of the people handling animals and working in farms and hatcheries	People working with and handling animals may only carry out tasks for which they are trained and competent. A clear training policy covering animal welfare should be in place.
Transportation	Minimal stress during housing, depopulation, transport and slaughter	Follow animal welfare regulations carefully , using trained supervisors, animal handlers and drivers. Only animals fit for transport should be loaded. Only vehicles designed for the species and distance/time in transit should be used.
Compartmentalisation and zoning	Ensuring availability of breeding stock/material in case of disease outbreaks	BO have pedigree programmes which also operate under high health conditions so that OIE compartmentalisation or zoning of areas allows for continuing supply chain operation to market.

PART II TECHNOLOGY

A. Breeding

Technology	Explanation
Chick sexing	Various methods are available to determine the sex of day-old poultry: - vent sexing (necessary in pure-lines and some crossbred lines.) - colour-sexing (used in brown-egg type layers) - feather-sexing (used in white-egg type layers and some broilers) - eye-colour-sexing (used in some duck breeds) The required sex ratio in parents is about 1:10; only one sex of grand parents and parents is sold; and males of egg-type chickens are of no value for meat production. For these three reasons, a high number of "off-sex" day-old chicks have to be disposed of at day-old in the hatcheries of layer breeders. Breeders have not found a satisfactory alternative to this practice, which is criticised on ethical grounds. Off-sex chicks of broiler breeders are reared as broilers and so have economic value.
Embryo sexing	Semen sexing as in mammals is not possible in poultry, because the hen determines the sex of the progeny. Embryos can be sexed at an early stage of incubation, currently various technologies are under development to improve the accuracy, success rate of early embryo sex determination and subsequent hatch.
Challenge tests	Challenge tests are used to select for better resistance to disease or against behavioural problems like cannibalism. These relatively small scale tests are necessary to improve the health status and welfare of large populations.
Sibling and Genotype by Environment testing	Family members of pedigree lines are raised under commercial conditions to be able to distinguish more robust families.
Genomics	The inclusion of genomics information in the routine selection of pedigree lines has started in poultry breeding and is expected to be implemented more widely during the coming decades. Genomics allows the BOs to make more accurate selection decisions and to evaluate important attributes for which there are limited measurable characteristics of an individual bird's record (ex: sex-limited traits at the time of selection) or for traits that can only be measured at a later point in life (e.g. liveability, egg production). . Genomics also allows for the genetic configuration of each bird and what traits have been inherited from its

	parents. Genomics is used as an additional tool in the breeding programme.
DNA markers	DNA markers can be used for various purposes: • The pedigree of a breeding population can be determined based on marker information. • Marker assisted selection (MAS) can be applied and can be particularly effective for traits, such as disease resistance, that are difficult to record on standard flocks. • Whole genome selection can be applied when informative markers that cover the whole genome are available. This renders less necessary the direct recording of traits on tested individuals. • Under the condition of abundance of informative markers, genetic variation can be monitored and maintained more effectively.

B. Reproduction

Technology	**Explanation**
Artificial insemination (AI)	Artificial insemination is used to a limited extent in chicken breeding and production to reproduce selected pedigree stock, grandparent stock, parent stock. Modern turkeys display all the same behaviours as traditional breeds for mating behaviour, and they can produce fertile eggs and good quality poults. Turkey breeding has in the same way as is common with other species, moved over time to Artificial Insemination to be able to increase the genetic progress which can be delivered and also to prevent venereal disease. Turkey natural mating behaviour is not very gentle and can cause damage to the females thus artificial insemination reduces this impact. In duck, it is used only for some breeds.
Controlled feeding	To maintain correct bird weight, to increase longevity and reproduction, breeding programmes may use various feeding and husbandry practices. Controlled feeding (via caloric restriction, feeding allocation programmes, and/or restriction of quantity fed per bird) may be used to during the rearing period of both male and female poultry so that they will achieve optimal rates of skeletal growth, physiological development, body composition and maturation.
Freezing semen	Freezing semen will be used to store genetic material by national conservation programme or to create companies' gene bank
Trap-nest pedigree pens	Pedigreed breeding females are often placed in single-male pens in order to track the origin of the eggs and subsequently the chicks, so that the breeding program has complete record of the sire and dam of each pedigreed chick.