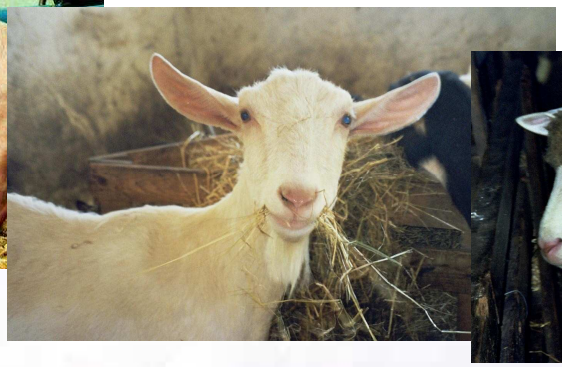
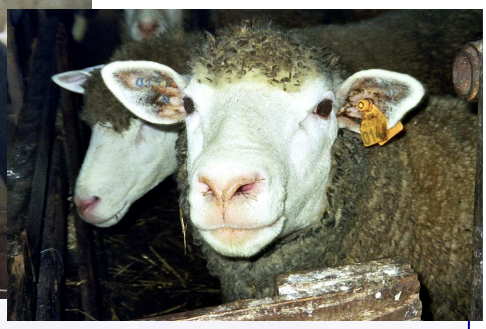
FABRE • TP

Sustainable Farm Animal Breeding & Reproduction Technology Platform





Implementation Plan

2008

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FABRE Technology Platform

Sustainable Farm Animal Breeding and Reproduction Technology Platform

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Contents

Introduction

Animal Breeding aims at exploiting in a sustainable manner genetic variation within and between breeds in genetic improvement programmes to enhance competitiveness and sustainability of EU animal food production. Estimation of breeding values plays a central role in most improvement programmes. These procedures need to be improved to capitalise on the increased understanding of the underlying genetic mechanisms on the one hand and the increased range of characteristics on the other. Reproduction techniques have an important influence on the optimal design of improvement and dissemination programmes that yield the desired genetic improvement while restricting the degree of inbreeding. Animal improvement programmes should focus on safe exploitation of genetic variation between animals to:

- produce better-quality, healthy, affordable, diverse food products offering consumers in and beyond Europe real options for improving their quality of life;
- promote a more sustainable agriculture and aquaculture, including emphasis on non-food functions of animals such as pleasure, leisure, or use in the medical area;
- enhance the competitiveness of European agriculture and aquaculture and its organisations;
- build the basis for implementing high-quality and sustainable breeding strategies in developing countries.

The key opportunities underlying the Sustainable Farm Animal Breeding and Reproduction Technology Platform (FABRE TP) are the world wide recognition of the European strength in the field population and quantitative genetics, the availability of a wide range of genetic resources of high value, the high quality of the breeding organisation, including reproduction biotechnology centres and performance recording networks. Europe is, therefore, well positioned to rapidly transfer developments in science to a more profitable and sustainable agriculture and aquaculture.
The European breeding industry can be characterised by its high scientific and technological level that ensures the high value of its products and determines its leading role in the world market. The industry is well positioned to adopt new technologies such as genome wide selection. This, however, requires a continued and substantial investment in research.

This Implementation Plan describes the research efforts that need to be undertaken and the implementation that has to be put in place for Europe to maintain its leading role in animal breeding and reproduction, and to provide the European citizens with a diverse choice of affordable, safe and diverse quality animal foods, and the European landscape and culture with an attractive liveable countryside, a large sustainable variety of animal breeds, and tasteful local and typical animal food products.
The Plan is based on the Vision Paper for 2025, and the Strategic Research Agenda (SRA) which have been developed with over 1000 specialists in Europe. The SRA effort involved thirteen expert groups, horizontal work on sociology, ethics, animal welfare, consumer research and economy, scenario development, and society discussion, and thirty four country discussions.

1. Reproductive Technologies

Reproductive techniques have been used for decades to enable safe and efficient breeding and are indispensable for efficient animal breeding.

a. Basic Reproductive Technologies

The level of implementation of reproductive techniques varies between animal species and between countries. It is affected by e.g. infrastructural differences, differences in availability of the techniques (Artificial Insemination (AI), Embryo Technology (ET)) as a commercial service or because of lack of knowledge and practical methods in certain species, often due to anatomical and physiological limitations.

Reproductive techniques are important tools to optimise breeding programmes, allowing dissemination of genes of interest. Therefore it is important to fill the gaps of knowledge and further develop practical methods in order to facilitate the use of both old and new reproductive techniques thus enhancing the competitiveness of EU farmers and food producers.

There is a need to coordinate the EU research agenda for an optimal output. Therefore, national and international policymakers and research funding organisations should be encouraged to develop a coherent yet flexible European research base in animal breeding and reproduction. The focus is on improving practical exploitation of reproductive techniques and domestication of aquaculture species:

- Improving AI and In Vitro Fertilisation (IVF) capabilities and efficiency in a range of species
- Improving current semen sexing technologies
- Closed breeding cycles for species undergoing domestication
- Improving cryopreservation of gametes, embryos and somatic cells
- Improving biosecurity.

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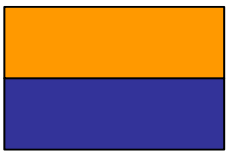				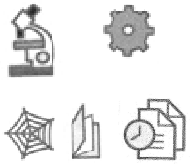

b. Advanced Reproductive Technologies

It is important that Europe maintains and further develops its skills in advanced reproductive technologies to be able to weigh the opportunities and possible disadvantages of these technologies. The development of these technologies should take place in a transparent way, and in continuous dialogue with European society. We advise that basic and coordinated research on these technologies will be funded from governmental resources for the following reasons: 1) publicly funded research is 'owned by all' – it will enhance the trust and transparency – this is what the general public deserves; 2) research on new technologies should not get lost for Europe, as we should be able to judge by our own means the developments, possible risks for animal health or welfare, etc, in order to be able take an underpinned point of view. We anticipate research on:

- Derivation, maintenance and control of differentiation of livestock stem cells
- Improved capability for use of GM technologies to generate new traits and new combinations of traits
- Improved capability for nuclear transfer
- Novel technologies for control of epigenetic factors

15-25 years

- In vitro gametogenesis and selection.

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	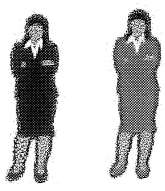			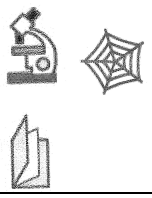

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2. Phenomics

The gathering of reliable data and definition of traits are the basis of effective selection programmes.

a. Trait Recording

The genetic variation underlying physiology of farm animals, environmental impact, and animal welfare need objective research. Therefore, it will be important to develop improved tools and the capability to measure and record traits:

- Improved cost-effectiveness of existing measurement tools
- Development of novel (to animal agriculture) measurement technologies
- Agreed trait ontologies.

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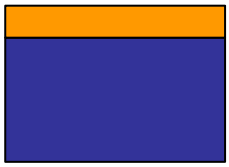	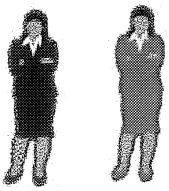			

b. Data Capture

Management systems will change, and identification and quality systems will become commonplace. Among them automatic identification and recording systems will be used more systematically to trace products along the whole production chain. This will provide new opportunities to record performance data in open selection programmes or record entirely new traits related to health and welfare. These systems will also enable the results of animal breeding to be tested (e.g. have we really achieved improved bone quality?), allow comparability of data over countries and between species and the use of large data sets for research. International efforts will be necessary to achieve comparable data gathering, arrange IP issues and enhance availability of the data. Systems to capture and utilise relevant information throughout the production and supply chain include:

- Electronic Identification technologies
- Genomic relatedness and traceability technologies
- Electronic data capture, storage and retrieval systems
- Data interchange and access protocols.

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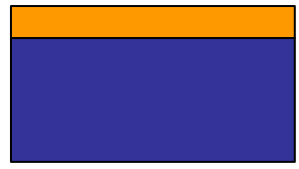				

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3. Genetics

The key opportunities in animal breeding concern increasing our understanding of factors contributing to genetic variation and the development of schemes that make optimal use of genetic variation while restricting the degree of inbreeding.

a. New Analytical Tools

Future qualitative and quantitative genetic technology will give breeders much control over the genetic makeup of individual animals selected for breeding. Population-level effects also deserve consideration, as 1) social interactions in groups of animals are associated with behavioural repertoires important for animal welfare and for proper functioning of the group, 2) the expression of production potential inherent in an animal's genes depends on nutritional, climatic, infectious, and social environment, which also includes the important role of the breeders, 3) disease transmission is a crucial population-level issue which involves two players: the host and pathogen. There is a need for research focusing on new genetic methodologies and tools to analyse interpret and predict.

- Performance across a range of environments
- Heterotic interactions across a range of genetic backgrounds
- Non-linear relationships among traits
- Population level interactions
- Epistatic interactions
- Developing programmes to integrate knowledge of reproductive technologies (AI, ET, IVF, embryo and gamete preservation)
- New methods for genetic evaluation (including genomics) to design and verify the efficiency of appropriate genetic schemes aiming to optimise multiple character selection and/or maintenance of biodiversity.

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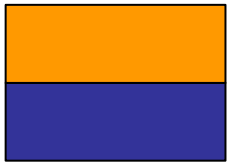	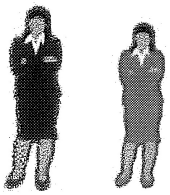			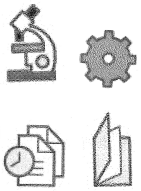

b. Combining Quantitative and Molecular Genetics Information

The wealth of genomic information will need extra scientific efforts to find its implementation into breeding programmes – therefore, improved tools to utilise quantitative information and/or molecular genetics information in selection need to be developed:

- Marker Assisted and Gene Assisted Selection
- Genome-Wide Selection
- Optimisation of diversity and heterosis in breeding systems
- Optimised breeding programme design.

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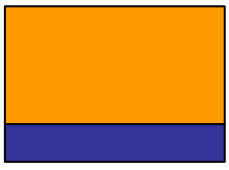				

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4. Genomics

A primary aim of farm animal genome research is to understand the genetic control of agriculturally, economically or biologically important traits. In addition, these species have considerable importance as models for understanding important biological process, for example, vertebrate development using chickens as a model.
Biological science over the past decade and more has been dominated by reductionist approaches typified by the genome projects. With the acquisition of complete genome sequences for humans and several model organisms the emphasis more recently has returned to more integrative, holistic approaches termed systems biology. Systems biology provides an appropriate scientific context and strategy for the needs of the farmed animal sector. The growing awareness of the finite nature of the planet's resources means that changes are needed in many economic sectors, including animal production systems, to address environmental issues and more generally sustainability. It is necessary not only to understand animals as biological systems, but also the impact of animals on their environment and vice versa. Thus, the scientific strategy for sustainable animal breeding and reproduction needs to address '*animal as systems* and *animals in system*'.
The development and testing of models lie at the heart of systems biology research. Predictive models are not only required for the pursuit of knowledge and greater understanding of animal systems, but also to inform improvements in sustainable animal breeding, production and reproduction. The virtuous cycle of predictive systems biology research to enable and inform improvements in sustainable animal breeding and reproduction requires modeling, experiments, tools and resources.

a. Basic Genomic Tools

The following basic tools for genomic research will need to be developed:

- Finished genome sequence for chicken, cattle, pig, salmon and sheep (horse)
- Draft sequence for duck, turkey, goat, trout
- Bioinformatic tools for open-access annotation and interrogation within and across species
- SNP panels (validated SNP panels with 0.5 to 1M SNPs for each target species)
- Tools to analyse copy number variations (CNVs) such as BAC tiling arrays and high density SNP arrays
- Transcriptomic tools
- Other 'omics tools
- Implementation of new sequencing technology for the analysis of farm animal genomes.

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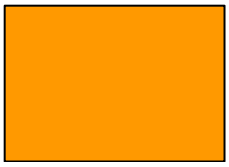				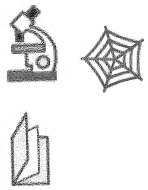

b. Tool Development for Trait Analysis

Tools need to be developed for the elucidation of complex genetic traits from genomic information:

- Gene-gene interactions
- Gene networks
- Heterosis and epistasis
- Epigenetic effects
- Environmental interactions.

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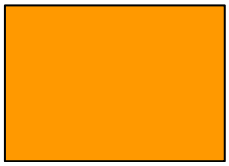	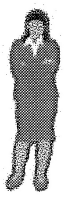			

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5. Technology Transfer

The **increasing gap between what is happening in research and the breeding practice** (of the average size breeding organisation) must be **recognised and addressed**. We need to:

- Optimise **research to applicable results** by increasing exchange of knowledge and technologies.
- Increase **collaborations** between research and industry, decreasing the distance between new knowledge and new products.

Public funding normally supports activity at the front of the R&D pipeline with industry picking up the costs once the uncertainties and risks are reduced to the point that a return on 'shareholder' investment can be realistically envisaged. The point along the pipeline at which industry is willing to invest varies by sector and the investment returns in agriculture are generally low. Therefore, public funders need to ensure they are willing to fund both basic and strategic research relevant to farm animal breeding and reproduction if we are to realise the promise offered by current developments in the biological sciences. Mechanisms that support shared-cost projects between industry and public funds in the middle of the pipeline are particularly valuable mechanisms that should be developed further.

Technology transfer needs to be(come) an integral part of research. It is crucial for innovations to be implemented continuously. However, it is complicated for scientific results, and what is more important, the opportunities for the practice of scientific results, to get their way to the breeding and AI organisations. The old situation of implementation from R&D in an institute/university to the R, S & D in a company is a top down approach that is not working anymore – a more interactive approach is needed. R&D of the **industry** will (need to be) more **involved in/with the research in the institutions**. Examples of technology transfer are

- inclusion of breeding organisations in research projects
- government-industry-research programmes
- Club of Interest around (complicated, precompetitive) research /education project
- technology transfer facilitators partnering several (small scale) industries and research organisations.

Public funding support of the pipeline should include appropriate structures and mechanisms that promote both i) business development from the research base, and ii) product and process innovation in industry. Knowledge transfer networks or similar mechanisms that deliver two-way facilitation at the interface of scientific capability and industrial need within specific technology sectors are valuable mechanisms. In the animal breeding and reproduction sector the combination of excellent scientific opportunities and structural challenges within industry mean that public support of relevant knowledge transfer mechanisms is appropriate if the potential benefits are to be realised.

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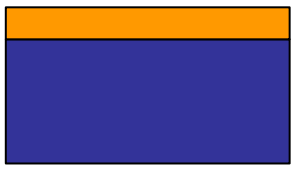	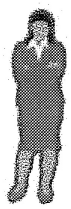			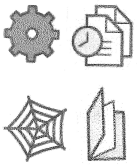

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6. Education

a. Young People

High quality research needs to feed an effective R&D and innovation pipeline that delivers new or improved products and processes. To be effective and efficient, support is needed for:

People Development - skills of scientists and knowledge transfer (KT) professionals working in the research base and industry by means of:

- High-quality education encouraging a constant flow of young people interested in careers in the biological sciences applicable to animal agriculture
- Graduates with the skills needed by the research base and industry including the interface of mathematics and biology and of genomics/genetics and reproduction
- PhD training (at least 100 new PhD graduates per year in the EU) covering scientific and innovation skills
- Encouragement of young scientists to take up research or innovation careers in our sector and to remain in our sector as they grow in skills and experience
- Access to training in specialist skills (including KT and innovation)
- Recognition that KT requires skilled professionals who understand and work with both the research base and industry. These individuals need appropriate training, public funding support and career opportunities. Fine-tuning with industry of methods, what works etc. is vital
- Fostering continuous professional development through distance and life-long learning mechanisms
- People movement and sharing of best practice among and between the research base and industry through mobility funding
- Effective networks, partnering schemes and communication channels for professionals in the sector (industry and academia) to access up to date information, advice and services related to science, innovation and best practice across the whole EU and to propose common research programmes to the EU.

Research and Innovation Structures at both national and EU level need to ensure a healthy R&D pipeline with an appropriate balance between:

- 'Blue-skies' basic research of unknown application
- Strategic pre-competitive research aimed at particular applications or challenges
- Applied research with a direct and near market application in mind
- Innovation and development that convert scientific developments into wealth creation or other societal improvements.

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	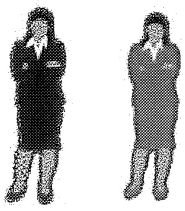			

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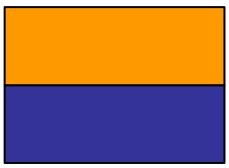
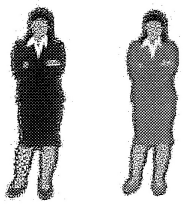
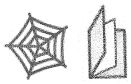
b. Continuous Professional Development

- **People Development** There needs to be continuous education of people at various agricultural genetics/reproduction levels. If this is done by educational organisations, e.g. universities – the education can result in an officially recognised diploma/degree. Next to continuous education of people in small scale industries there is a need for the education from scientists and industry people in Eastern Europe.
- **Innovative life long learning mechanisms.** A good inventory of the current practices, the needs of the industry, and how to meet these in the best way needs to be developed. Depending on the country various systems are or have been available for this. The good practices can be studied and applied in adapted form to other regions. There should come subsidies available for the education of industry people, especially for the small scale industries.

Action and Timeline 5 10 15 y	Human Resource	Funding Distribution	Funding Amount	Type of Activity
				

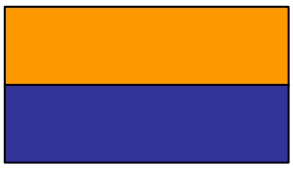
Description of the Table Symbols page 12

7. Socio-Economic Development

Breeding nor animal food production take place in isolation. It is important that the socio-economic aspects are being taken into account in the development of research and implementation in Europe and globally. This includes:

- **forecasting of and dealing with** breeding business related to pre-competitive and animal health/society/ethical/transparency issues, including outlook methods to include consumer and society feedback in breeding programme development
- for governments to invest in **new technologies in a transparent way**, and in dialogue with all stakeholders, from farming to consumers.
- investigation and implementation of a suitable sustainable framework for the protection and exploitation of **intellectual property** that encourages investment by industry in R&D
- development of **dialogue and transparency strategies** to involve society in the weighing of opportunities and concerns.
- **structures for developing**, agreeing and sharing **best practice** including industry standards and codes of practice
- **structures for watching** over industry standards (e.g. broad claims, patenting already running business) and codes of practice
- development of specific knowledge involving political, society, communication knowledge, to be able to make the **one way into a two way communication**, and to make the society agenda into an agenda in which society has a real stake
- establishment of structures for watching over **local, cultural standards**

Socio-economic research policy and outlook projects are important. They need to include **various stakeholders/social partners**. The safe environment of an EU project will enable various different partners to communicate and develop **practical tools or outlooks** while maintaining their own **professional independence and integrity**. It is of key importance that such projects should include the **'subject of study'** (in this case the breeding industry) **as an active and responsible partner**. Situations in which specialists start studying, debating and sidewise involving the 'subject of study' should be avoided as much as possible.

Action and Timeline 0 5 10 y	Human Resource	Funding Distribution	Funding Amount	Type of Activity
				

Description of the Table Symbols page 12

Enabling Factors

a. Networking

For the research and education investments to be effectively implemented in Europe, networking and cross-border cooperation will play an increasing role in the development of both competitive and diverse breeding for animal products across Europe. The science and technologies involved are broad and complicated. They need strategic networking, opening up research and research-industry network across country and regional borders. Also the education and exchange of scientists and professionals should be encouraged and become common practice if Europe wishes to profit fully from its investments in this area.

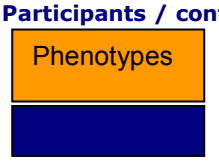
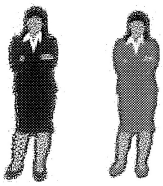
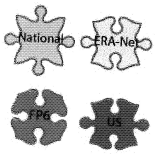
b. Transparency – Communication – Dialogue

Animal breeding and reproduction deal with food, animals, genes, new technologies (whether real or perceived), selection, animal welfare, environmental output, competitiveness, taste, food choice, biodiversity. These are potentially sensitive issues. Farm animal breeding and reproduction research, education and practice have a responsibility towards society to be transparent, communicate and develop a two way dialogue with society.

c. Regulatory Climate

Animal breeding and reproduction operate at an open global, competitive market. It is of key importance that the regulatory climate is supportive and practical while taking into account the place of breeding in Europe's society. This includes measures based on facts. Breeding organisations realize the importance of taking their responsibility towards society and policy development in contributing cooperatively to society and regulatory issues at the earliest possible stage. This includes taking the responsibility to work together among competitors, species, market segments, and regions and undertaking serious efforts to support the development of a responsible yet practical regulatory climate.

Explanation of Table Symbols

Icon	Description
Participants / contribution 	The arrows describe start and duration of the project as well as the contributions needed from academia and industry. Orange stands for academia, blue for industry. The ratio of this contribution is depicted by the area ratio within the arrow.
Project Type 	Different types of projects might be needed depending on the envisaged activity: • ***Research projects:*** Projects ranging from frontier/basic research to applied, pre-competitive research which primary aim is to generate scientific and technical knowledge which can be further used for the development of new innovative products and/or improving the sustainability of existing production. These projects will benefit from collaboration efforts and networks.
	• ***Demonstration / Pilot project:*** Projects with the aim of demonstrating the industrial and economic feasibility, and the sustainability of a concept.
	• ***Studies:*** These projects, including surveys, feasibility studies, LCA or eco-efficiency analysis, aim at generating knowledge/information allowing stakeholders and decision-makers to make informed choices.
	• ***Network / Coordination:*** Networks and coordination projects will allow better coordination between stakeholders in a field, interdisciplinary cooperation, exchange of information and coordination between European and Member States level.
	• ***Training:*** Exchange/mobility of researchers, courses, projects influencing curricular programmes in Member States.
Distribution 	Activity funding might come from different resources. While a general overview of available funding sources for different project types is given in Chapter 2.2, the pie charts describe the envisaged distribution of funding sources for each activity. A distinction is made between private or industry funding (dark blue), European Union funding (white) and national funding (light blue). Possibilities for venture capital, if they exist, will be addressed in the text.
Funding amount 	Gives a scale for indicating the required resources for the total duration of the activity 1 stack of coins: < 5 Million € 2 stacks of coins: 5 - 15 Million € 3 stacks of coins: 15 - 25 Million € 4 stacks of coins: > 25 Million €
Human resources 	Activities require human resources with adequate training and expertise. A black symbol depicts that sufficient research expertise is or is likely to be available in Europe; a grey symbol means that such a skill base needs to be actively developed for a sufficient number of researchers.
Activities 	The Action Plan activities were selected based on the importance of the issue and the relevance to the overall challenges. It is often the case that other activities of relevance are already ongoing. New projects must build on such ongoing activities to achieve the best value. The puzzle pieces indicate whether significant, related and currently ongoing activities exist within the EU (FP6), at national level, in ERAnets, and/or in other regions of the world. More details of such activities are given in the description for each activity.

Stakeholders:

Aarhus Universitet, Agricultural Biotechnology Center, Associação de Criadores de Ovinos do Sul, Arbeitsgemeinschaft Deutscher Rinderzüchter, Associazione Italiana Allevatori, Akademia Techniczno-Rolnicza im. Jana i. Jedrzeja Sniadeckich w Bydgoszczy Wydzial Zootechniczny, Akvaforsk, Alta Genetics, Associazione Nazionale Allevatori Suini, Asociación Nacional de Criadores de Ganado Porcino Selecto, APEZ (Portuguese Association of Animal Science Engineering), Aristotle University of Thessaloniki, AquaGen, Aviagen, Biotechnology and Biological Sciences Research Council, British United Turkeys, CESTR (Czech Fleckvieh Breeders Association), CF Consulting Finanziamenti Unione Europea, Cherry Valley, Cobb Europe, CONVIS Herdbuch Service Elevage et Génétique Luxembourg, COPA-COGECA, Consiglio per la Ricerca e la Sperimentazione in Agricoltura, HG/CRV Holding, CECAV (Research Center of Animal and Veterinarian Sciences), Dansire, Danish Pig Production, Deutsche Reiterliche Vereinigung, Deutsche Gesellschaft für Züchtungskunde, European Association for Animal Production, European Aquaculture Society, European Forum of Farm Animal Breeders, Eesti Tousigade Aretushustu, Euribrid Hendrix Genetics, Europabio, FABA Breeding, Animal Production Service of Animal Production Service and Health Division of FAO, Federation of European Aquaculture Producers, Forschungsinstitut für biologischen Landbau, Forschungsinstitut für die Biologie landwirtschaftlicher Nutztiere, France Hybrides, Fugato, FUSAGx (Gembloux Agricultural University), Genesis Faraday, Gentec, Genus PIC, Hubbard Breeders, Hungarian Society of Agricultural Sciences, Institute for Animal Health, Institutul de Biologie si Nutriti Animala, International Committee for Animal Recording, Irish Cattle Breeding Federation, Instituto de Investigación y Tecnolog'ia Agraria y Agroalimentaria, Institut National de la Recherche Agronomique, Institute of Animal Science, National Centre of Agricultural Sciences, Kostinbrod, Bulgaria, Institute of Biology and Immunology of Reproduction, Bulgarian Academy of Sciences, Institute for Pig Genetics, Institut de Recerca i Tecnologia Agroalimentàries, Isituto Sperimentale Per La Zootecnia, Institut Technique du Porc, Katholiek Universiteit Leuven - Fac. Wetenschappen - Afd. Ecologie en Systematiek der Dieren - Laboratorium voor Aquatische Ecologie, Lohmann Tierzucht, Marine Harvest, Marine Institute, Foras na Mara, Merial, Meat and Livestock Commission, MTT Agrifood Research Finland, National Agricultural Research Foundation, Parco Tecnologico Padano, Norwegian School of Veterinary Science, Norsvin, Panhellenic Confederation of Unions of Agricultural Cooperatives, Pfizer Animal Health, Polish Academy of Sciences - Institute of Genetics and Animal Breeding, Scottish Agricultural C, Semenitaly, Slovak Agricultural Research Authority, Slovak Agricultural University in Nitra, Drustvo Rejcev Govedi Crnobele Pasme v Sloveniji, SperiVet, Dipartimento di Scienze Sperimental Veterinarie, Svensk Avel, SUISAG , Syndicat des Sélectionneurs Avicoles et Aquacoles Francais, Teagasc, TOPIGS, UCL Université Catholique de Louvain Faculté d'ingénerie biologique, agronomique et environmentale, ULg Université de Liége Faculté de Médecine Vétérinaire, Union Nationale des Coopératives agricoles d'Elevage et d'Insémination Animale, Universita Cattolica Piacenza, Università degli Studi di Milano Dipartimento di Scienze e Tecnologie Veterinarie per la Sicurezz Alimentare, Università degli Studie di Padova Dipartimento di Scienze Sperimentali Veterinarie, Università degli Studi di Palermo Dipartimento di Scienze Entomologiche, Fitopatologiche, Mircobiologiche Agrarie e Zootechniche, University of Bologna, University Bonn / Institute of Animal Science, University of Córdoba, University of Copenhagen, faculty of Life Sciences, University of Bedfordshire, University of Ljubljana, University of Newcastle / School of Agriculture, Food and Rural Development, University of Perugia, World Association for Animal Production, Wielkopolskie Centrum Hodowli i Rozrodu Zwierat w Poznaniu z siedziba w Tulcach, World's Poultry Science Association Federation of European Branches, Wageningen University and Research Center, Zentralverband der Deutschen Schweineproduktion

Observers from:

DG Sanco, European Food Safety Authority, Eurogroup for Animals, Joint Research Centre (Seville)

Mirror group *after finalisation country discussions*