CIHEAM
Centre International de Hautes Études Agronomiques Méditerranéennes

Animal Breeding and Reproduction Biotechnology

Organized by

Mediterranean Agronomic Institute of Zaragoza

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Jointly organized by: **Polytechnic University of Valencia (UPV), Autonomous University of Barcelona (UAB), CIHEAM-IAMZ, Valencian Institute for Agricultural Research (IVIA), National Institute for Agro-food Research and Technology (INIA) and Institute for Food and Agricultural Research and Technology (IRTA)**
Scientific coordinators: **Prof. Dr. Manuel Baselga, Prof. Dr. Armand Sánchez**
IAMZ coordinator: **Dr. Armando Occón**

The Master on Animal Breeding and Reproduction Biotechnology provides a two-year programme for graduates who wish to specialize in the subject, and professionals interested in updating their knowledge.

In the first year participants follow the Postgraduate Specialization Course. Formal lectures are complemented by laboratory practicals, computer practicals, round table discussions and technical visits.

In the second year, students who have successfully completed the first year develop an individual work of initiation to research or to professional activity on a chosen topic of the specialization, leading to a Master of Science Degree.

The programme is held every two years. Next edition starts in October 2009.

Participants must hold a university degree in agronomy, veterinary sciences, animal sciences, biology or any related field. Knowledge of genetics and statistics is required.

The working language is Spanish, therefore participants should prove knowledge of Spanish at the start of the course. From the beginning of July to the end of September IAMZ organizes an intensive course of Spanish for those who require it. In the selection of candidates, knowledge of English is nevertheless valued, as part of the documentation distributed may be written in this language.

This Master is also an official Master of the Spanish University system.

Objectives

The objective of the first part of the Master programme (Postgraduate Specialisation Course) is to enable participants to: (i) update the scientific grounds of the disciplines that constitute animal breeding; (ii) acquire experience in the application of the most advanced methods and techniques and in the formulation of breeding strategies related to the main species of zootechnical interest; (iii) gain the necessary expertise to join programmes of molecular genetics, genetic improvement, reproduction biotechnology and conservation of genetic resources, providing alternatives that improve the effectiveness of such programmes; (iv) be competent in responding to the specific demands of administrations or firms; and (v) exchange enriching experiences and points of view through a programme developed in contact with the sector in an interprofessional and international environment.

Through the work carried out in the second part of the programme (Master Thesis), participants complete their training by making a critical application of the knowledge, methods and techniques acquired during the first year of specialization and develop their competence in: (i) analysis of problems; (ii) definition of objectives; (iii) acquisition and treatment of data in compliance to a pre-established research protocol; (iv) analysis of results; and (v) elaboration of conclusions that may contribute to clarify and find a possible solution to problems.

Part 1
Postgraduate specialisation course

Training is organized in 4 sections (60 ECTS)

Section 1 **MOLECULAR GENETICS**

Molecular genetics is making an increasing contribution to animal breeding. This section provides the molecular bases of animal breeding and the study of structural and functional genomics, reviewing current and innovative methodologies and techniques. Great importance is given to the practical part of this section, which is developed in the laboratory and through bioinformatics exercises.
Learning outcomes are: (i) to update the molecular bases of animal genetics; (ii) to gain experience concerning the main methodologies and techniques used in the study of the genetic information; (iii) to acquire competence in the most relevant molecular analysis carried out in the laboratory, related to nucleic acids, sequencing and genotyping; and (iv) to develop skills in the use of bioinformatics tools.

Section 2 **POPULATION AND QUANTITATIVE GENETICS**

After presenting the fundamentals of statistics relevant to breeding and selection processes, this section deals with population genetics and quantitative genetics, the two disciplines that to date have been responsible for the main advances in the breeds and populations of the animals used in production, studying in depth the main concepts and methodologies involved in animal breeding.
Learning outcomes are: (i) to update the statistical bases relevant to data analysis and experimental design in animal breeding programmes; (ii) to know the principles that determine genetic variability and gene function; (iii) to understand the most important factors determining gene and genotype frequencies and the maintenance of variability; (iv) to identify the types of gene action and to master the estimation of their corresponding parameters and the selection methods to make a better use of it; (v) to become familiar with the computer software used in this discipline and to gain practical experience in data mining and analysis.

Section 3 **GENETIC RESOURCES AND BREEDING PROGRAMMES**

Conservation and management of animal genetic resources is reviewed, considering the genetic aspects involved and the existing strategies for the different species and situations. This section, then, presents outstanding breeding programmes dealing with different types of production and species, thus illustrating the possible breeding strategies, methodologies and technics studied in the two previous sections.
Learning outcomes are: (i) to be aware of the necessity and utility of developing genetic resources conservation programmes; (ii) to know the main elements necessary to adequately manage a genetic resource programme; (iii) to be able to define and integrate the different components that interact in the design of a breeding programme and in its application planning; (iv) to apply the principles and methodologies presented in the previous sections; (v) to make a critical assessment of different breeding alternatives and strategies; and (vi) to exchange ideas with the professionals currently carrying out the design and management of real breeding programmes.

Section 4 **REPRODUCTION BIOTECHNOLOGY APPLIED TO ANIMAL BREEDING**

Reproduction biotechnology offers tools to enhance and facilitate the application of both quantitative and molecular breeding methods This section first presents the fundamentals of reproduction in farm animals and the main techniques used. The section includes a practical part that is developed in the laboratory. Finally the section presents the recent advances of biotechnology through the review of current reproduction programmes carried out in different species.
Learning outcomes are: (i) to update the fundamentals of reproduction that led to the understanding of the techniques relevant to breeding programmes; (ii) to review and assess the main reproduction methodologies and techniques that increase the reproductive efficacy of the selected individuals or those allowing the manipulation of gametes and cells for a breeding purpose; (iii) to develop skills in laboratory techniques for embryo production and for sperm and embryo recuperation and conservation; (iv) to gain experience in the assessment of real applied programmes; and (v) to favour the exchange of ideas with the professionals of the sector directly involved in reproduction biotechnology activities.

TRAINING SEQUENCE

Section 1 (20 ECTS) Dates: from 1 October to 20 December 2007.	**MOLECULAR GENETICS** **Unit 1** – Molecular bases of animal genetics (5 ECTS), **Unit 2** – Animal genomics (5 ECTS), **Unit 3** – Laboratory of molecular genetics (5 ECTS), **Unit 4** – Bioinformatics practicals (5 ECTS).
Section 2 (17.5 ECTS) Dates: from 7 January to 14 March 2008.	**POPULATION AND QUANTITATIVE GENETICS** **Unit 1** – Fundamentals of statistics (2 ECTS), **Unit 2** – Population genetics (2 ECTS), **Unit 3** – Quantitative genetics I (5.5 ECTS), **Unit 4** – Quantitative genetics II (4 ECTS), **Unit 5** – Quantitative genetics III (4 ECTS).
Section 3 (10 ECTS) Dates: from 31 March to 25 April 2008.	**GENETIC RESOURCES AND BREEDING PROGRAMMES** **Unit 1** – Genetic resources management and conservation (3 ECTS), **Unit 2** – Breeding programmes (7 ECTS).
Section 4 (12.5 ECTS) Dates: from 28 April to 6 June 2008.	**REPRODUCTION BIOTECHNOLOGY APPLIED TO ANIMAL BREEDING** **Unit 1** – Reproduction fundamentals and techniques (5 ECTS), **Unit 2** – Practicals in reproduction techniques (3.5 ECTS), **Unit 3** – Reproduction biotechnologies per specie: cattle, sheep, goats, pigs, rabbits, poultry (4 ECTS).

Comprehensive oral or written examination

Participants take 2 written examination for Sections 1 and 2, and 1 written examination for Sections 3 and 4. Each unit is independently graded.
Written exams consist of a set of questions that require a concise answer. Some of the questions are multiple choice. Lengthy questions are avoided.
Participants may retake failed exams once.

Analytical syllabus

Section 1 **MOLECULAR GENETICS**

Unit 1 – Molecular bases of animal genetics
Basic concepts of animal genetics. Organization and structure of the eukaryotic genome. Control of gene expression in eukaryotes. Molecular techniques to study variability. Genetic markers

Unit 2 – Animal genomics
Structural genomics: genetic maps; comparative mapping; gene identification; genome sequencing: strategies and results.
Functional genomics: general techniques in the studies of gene function; microarrays; proteome analysis; mutation-independent techniques; molecular bases for disease resistance; animal transgenics and modifications of the genome

Unit 3 – Laboratory of molecular genetics
This unit is based on practical work carried out in the laboratory. Practicals are:
Extraction and quantification of nucleic acids (DNA and RNA) from different types of biological samples.
Electrophoresis of nucleic acid using agarose and acrylamide gels and capillary electrophoresis.
DNA amplification. Conventional PCR, RT-PCR and quantitative PCR.
Analysis of amplified products: DNA sequencing.
Microsatellite genotyping.
SNP genotyping: RFLPs, Primer Extension Analysis, SNPlex, Pyrosequencing, allele discrimination by TaqMan probes.

Unit 4 – Bioinformatics practicals
The unit is based on practical computer work. Practicals are:
Design and optimization of PCR primers.
Use of DNA and protein databases.
Sequence alignment: BLAST, CLUSTAL.
Interpretation of sequencing results: sequence analysis.
Microsatellites analysis: pattern interpretation.
Problem solving in electropherogram interpretation
Use of software packages in the molecular marker analysis.
Molecular phylogenies (PHYLIP)
Analysis of gene expression data obtained through microarrays.

Section 2 POPULATION AND QUANTITATIVE GENETICS

Unit 1 – Fundamentals of statistics

Introduction to the basic concepts of statistics and matrix calculus relevant to the quantitative genetics.

Unit 2 – Population genetics

Infinite random mating populations: introduction; panmictic finite populations; gene frequency estimation and random mating tests; coancestry mating; finite populations.

Unit 3 – Quantitative genetics I

Variation and types of gene action: continuous variation, gene effects heritability; threshold characters, genetic correlation.
Concepts and basic types of selection by additive value: individual selection; prediction of the additive value; selection methods; multiple selection for several traits.

Unit 4 – Quantitative genetics II

Mixed linear model: linear models; estimation; prediction; the animal model; the problem with the base population; other animal models; multivariate animal models.
Detection and use of QTLs: linkage analysis; statistical aspects; gene introgression; marker-assisted selection.
Crossbreeding: the use of the non-additive genetic variation; recurrent selection; reciprocal recurrent selection; crossbreeding in animal production.

Unit 5 – Quantitative genetics III

Estimation of variance components.
Random regression.
Bayesian estimation: introduction; McMC; mixed model.
Analysis and experimental design in animal breeding.

Section 3 GENETIC RESOURCES AND BREEDING PROGRAMMES

Unit 1 – Genetic resources management and conservation

Decline and conservation of the genetic diversity of domestic animals.
Genetic diversity: origin, types and assessment; driving forces affecting genetic diversity; genetic shift and effective census.
Genealogical analysis: coancestry and inbreeding; other parameters in the genealogical analysis; inbreeding depression; practicals.
Population structure: analysis of the genetic diversity; genetic distance between populations of domestic animals; genetic singularity; practicals.
Genetic management in conservation programmes: choice of the populations and the conservation method; general methodology – minimization of coancestry; maintenance of the allelic diversity; practicals on gamete bank design.
Marker-assisted conservation: practicals on paternity analysis and coancestry estimation; the optimization of conservation programmes through the use of markers.
Animal resources conservation in the world.

Unit 2 – Breeding programmes

This unit reviews current breeding programmes carried out in different countries and institutions, to exemplify the different breeding methodologies and technics studied in previous sections using an applied approach. The species dealt with are: dairy and beef cattle, dairy and meat sheep, goats, pigs, poultry, rabbits and aquaculture species. To conclude, the unit reviews the applications of breeding in the case of developing countries.

Technical visits and round table discussions are organized to illustrate these breeding programmes for different species.

Section 4 REPRODUCTION BIOTECHNOLOGY APPLIED TO ANIMAL BREEDING

Unit 1 – Reproduction fundamentals and techniques

Bases of reproduction: reproduction endocrinology; spermatogenesis; oogenesis and follicle genesis; estrous cycle; fecundation, embryo development, pregnancy and labor; factors affecting reproduction; reproduction pathologies.

Semen technology: recuperation; techniques for quality assessment; conservation methods; sperm sexing.

In vivo oocyte and embryo production: superovulation treatments; Ovum Pick-Up (OPU); laparoscopy.

In vitro embryo production: *in vitro* maturation; *in vitro* fecundation; intra-cytoplasmic injection; *in vitro* embryo culture; assessment of embryo quality

Embryo transfer.

Fundamentals of cryobiology: cryoconservation of oocytes and embryos.

Transgenic embyro production. Microinjection, ICSI and somatic cloning.

Unit 2 – Practicals in reproduction techniques

The unit is based on practical work carried out in the laboratory. Practicals are:

Sperm recuperation, analysis and freezing.

Defrosting, synchronization and artificial insemination.

In vitro embryo production: *in vitro* maturation, *in vitro* fecundation, embryo culture.

Embryo recuperation and freezing.

Unit 3 – Reproduction biotechnologies per specie

This unit reviews current reproduction biotechnology programmes carried out in different institutions. The species dealt with are: cattle, sheep, goats, pigs, rabbits and poultry.

Three round table discussions are organized, respectively dealing with: (i) the setting-up and management of germplasm banks and sanitary control; (ii) current state of sperm conservation and artificial insemination; and (iii) the problems of embryo production, conservation and transfer.

Various technical visits to insemination centres illustrate the methodology and techniques explained throughout the unit.

Part 2
The Master of Science thesis

Project (10 month duration, 60 ECTS)

This part of the programme is carried out in the organizing institutions and other well-recognized institutions (universities, research centres or firms), generally throughout Spain or in the participant's country of origin, under the scientific supervision of a thesis director that must be a doctor of renowned prestige. Participants choose the topic according to their interest of training, which is approved by a Committee. If the participant so requires, the organizing institutions advise on the choice of the most appropriate thesis director and institution to carry out the desired project, and likewise propose topics related to their research activities or other topics of interest previously accorded with other institutions.

This is the first edition of the Master, and that is the reason why the experience related to this discipline comes from a previous Master on Animal Production that was held at IAMZ from 1979 to 2006, in which animal breeding and reproduction were two of the three main areas studied. In the previous Master, the theses related to breeding frequently dealt with the estimation of genetic parameters and breeding values of production and quality traits of specific breeds; others focus on the analysis of molecular markers of interesting traits. Theses on reproduction biotechnology usually dealt with issues related to semen quality and conservation. So, a wide range of research topics available for Master of Science theses is foreseen, considering that the above-mentioned topics will be treated more in depth and other innovative subjects have been introduced in the new Master.

The participant, with the support of the thesis director, should inform the organizing institutions periodically on the development and progress of the research work. This part concludes with the writing of a thesis to be defended in public before an examining board convened by the organizing institutions. The jury is composed of representatives of the organizing institutions and other external members selected in each case for their expertise and prestige in the field of the thesis.

INDICATIVE MASTER THESES REALISED WITHIN THE AREA OF ANIMAL BREEDING AND REPRODUCTION BIOTECHNOLOGY DURING THE PREVIOUS MASTER ON ANIMAL PRODUCTION HELD FROM 1979 TO 2006

Title: Molecular analysis of the goat lipoprotein lipase and acetyl-coenzyme A carboxylase α-genes (2006)
Author: Bouabid Badaoui, Agronomist, Morocco
Place of realization: Departamento de Ciencia Animal y de los Alimentos, Unidad de Genética y Mejora, Facultad de Veterinaria, Universidad Autónoma de Barcelona, Spain
Thesis director: Marcel Amills

Title: Adaptation and application of superovulation techniques to produce and preserve embryos of the breeds *Rubia del Molar* and *Negra del Colmenar* (2005)
Author: Imad Ammoun, Agronomist, Lebanon
Place of realization: Unidad de Reproducción, Departamento de Toxicología y Farmacología, Facultad de Veterinaria, Universidad Complutense de Madrid, Spain
Thesis directors: Teresa Encinas and Antonio González de Bulnes

Title: Genetic polymorphism in goats. Study of the beta-lactoglobulin, the kappa casein, and stearoyl coenzyme A desaturase genes (2000)
Author: Habib Yahyaoui, Agronomist, Tunisia
Place of realization: Departamento de Patología y Producción Animal, Facultad de Veterinaria, Universidad Autónoma de Barcelona, Spain
Thesis director: Armand Sánchez and José María Folch

Title: Identification of type I and II genetic markers in the genome of animals of livestock interest (1997)
Author: Carmela Senese, Agronomist, Italy
Place of realization: Dipartimento di Scienze delle Produzioni Animali, Facoltà di Agraria, Università degli Studi della Basilicata, Potenza, Italy
Thesis director: Piero Masina

REFERENCES OF THE MAIN ACADEMIC STAFF TEACHING WITHIN THE M.SC. PROGRAMME

46 lecturers from 9 countries participate in the M.Sc. programme. Some of them belong to the organizing institutions and others are guest lecturers. 50% of the lecturers come from Research Centres, 48% from Higher Education Institutions and 2% from International Centres. Considering their implication in the programme, the following academic staff is taken as reference:

- Manuel **BASELGA**, Scientific coordinator, Univ. Politécnica de Valencia, Departamento de Ciencia Animal, Valencia (Spain)
- Armand **SÁNCHEZ**, Scientific coordinator, Univ. Autònoma de Barcelona (UAB), Departament de Ciencia Animal i dels Aliments, Bellaterra-Barcelona (Spain)
- Badi **BESBES**, Food and Agriculture Organisation of the United Nations (FAO), Roma (Italy)
- Jean Pierre **BIDANEL**, Institut National de la Recherche Agronomique (INRA), Station de Génétique Quantitative et Appliquée, Jouy-en-Josas (France)
- Agustín **BLASCO**, Univ. Politécnica de Valencia, Departamento de Ciencia Animal, Valencia (Spain)
- José María **FOLCH ALBAREDA**, Univ. Autònoma de Barcelona (UAB), Departament de Ciencia Animal i dels Aliments, Bellaterra-Barcelona (Spain)
- Eva **MOCÉ**, Instituto Valenciano de Investigaciones Agrarias (IVIA), Centro de Investigación y Tecnología Animal, Segorbe (Spain)
- Miguel **PÉREZ-ENCISO**, Institució Catalana de Recerca y Estudis Avançats - Univ. Autònoma de Barcelona (ICREA-UAB), Barcelona (Spain)
- Raul **PONZONI**, World Fish Center, Genetic Improvement Research Programme, Penang (Malaysia)
- Heriberto **RODRÍGUEZ-MARTÍNEZ**, Swedish Univ. Agric. Sciences, Department of Obstetrics and Gynaecology, Uppsala (Sweden)
- Daniel **SALAMONE**, Univ. de Buenos Aires, Departamento de Producción Animal, Buenos Aires (Argentina)
- Fermín **SAN PRIMITIVO**, Univ. de León, Departamento de Genética y Mejora, León (Spain)
- M.A. **SANTACREU**, Univ. Politécnica de Valencia, Departamento de Ciencia Animal, Valencia (Spain)
- Luis **SILIÓ**, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA), Departamento de Genética Animal, Madrid (Spain)
- Miguel Ángel **SILVESTRE**, Instituto Valenciano de Investigaciones Agrarias (IVIA), Centro de Investigación y Tecnología Animal, Segorbe (Spain)
- Daniel **SORENSEN**, National Institute of Animal Science (NIAS), Department of Animal Breeding and Genetics, Foulum (Denmark)
- Sipke-Joost **HIEMSTRA**, Wageningen UR, Institute for Animal Science and Health, Lelystad (the Netherlands)
- Joan **TIBAU**, Institut de Recerca i Tecnología Agroalimentàries (IRTA), Centre de Control de Produccions Porcines, Monells (Spain)
- Miguel Angel **TORO**, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA), Departamento de Genética Animal, Madrid (Spain)
- María Pilar **VIUDES**, Instituto Valenciano de Investigaciones Agrarias (IVIA), Centro de Investigación y Tecnología Animal, Segorbe (Spain)