Animal Breeding and Reproduction Biotechnology

Organized by

Mediterranean Agronomic Institute of Zaragoza

Animal Breeding and Reproduction Biotechnology

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), Institute for Food and Agricultural Research and Technology of Catalonia (IRTA)** and **Foundation of the Community of Valencia for Agro-food Research (AGROALIMED)**

Scientific coordinators: **Prof. Dr. Agustín Blasco, Prof. Dr. Armand Sánchez**

The programme is held every two years. Next edition starts in October 2009.
This Master is also an official Master of the Spanish University system.

Aims: Genetic improvement is a complex discipline bringing together relatively disparate subjects. On one hand, population and quantitative genetics, that to date have been responsible for the main advances in the breeds and populations of the animals used in production. On the other hand molecular genetics, of more recent development, that is making an increasing contribution to breeding. Finally, reproduction biotechnology, that offers tools to enhance and facilitate the application of both quantitative and molecular breeding methods. It is necessary to train young professionals and scientists in these disciplines so that, both from the public and private sectors they will have the operative capacity to establish, develop and evaluate animal breeding programmes.

Learning outcomes:

- To understand the basis and principles of modern animal breeding, and to know the advances offered by molecular genetics, quantitative genetics and reproduction biotechnology to achieve specific objectives and enhance the efficacy of breeding programmes
- To be able to integrate the different components of an animal breeding programme and to assess the advantages and drawbacks in the use of different strategies and methods, contributing alternatives that may improve the efficiency of the programmes from a perspective of productivity and production quality.
- To know how to design, develop and assess programmes of molecular genetics, breeding, reproduction biotechnology and conservation of genetic resources, for different livestock species in different situations and environments, responding to concrete demands from the administration, the livestock sector and consumers.
- To assume the responsibility of planning and carrying out, under the supervision of a tutor, but in a manner that must be largely autonomous, a work of initiation to research in animal genetics and breeding, whose results may be potentially publishable.
- To prove knowledge of the scientific and technical information underpinning the research conducted, command of the techniques and methodologies relevant to such research, and capacity to objectively evaluate the significance of its results and conclusions.
- To know how to communicate the reasoning and conclusions of tutored works carried out in a group or autonomously, to develop skills in the preparation of informative and synthetic documents, and to acquire experience in the preparation and presentation of oral communications delivered and defended before an audience.

Part 1
Postgraduate specialization programme

The programme is organized in 13 Units (60 ECTS)

Unit 1 **MOLECULAR BASES OF ANIMAL GENETICS (5 ECTS)**
05-30 Oct. '09

Content:
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

Learning outcomes:
- To update knowledge on the molecular basis of animal genetics.
- To know the genome organization and structure of the eucaryotic organisms and the control processes of gene expression.
- To value the importance of genetic variability, and to be able to assess its magnitude, locating gene regions linked with traits of interest for breeding, and determining the connexion between phenotypic and genotypic variability.
- To become familiar with the different types of molecular markers most used in animal genetic studies.
- To understand the main applications of molecular markers in genotype identification, location of genes of interest and analysis of quantitative traits, and to gain further insight into the application of molecular markers in selection, as a tool contributing to breed characterization and to assist the development of new breeds.

Unit 2 **ANIMAL GENOMICS (5 ECTS)**
02-16 Nov. '09

Content:
- Structural genomics: genetic maps; comparative mapping; gene identification; genome sequencing
- 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

Learning outcomes:
- To know the objective of genome analysis projects of certain model animal species, and the possibilities offered by their comparison with other important livestock species.
- To gain experience in the construction and comparison of genetic maps.
- To understand the interest of identifying genes and sequencing the genomes to know the gene structure and to identify loci affecting quantitative and qualitative traits of interest.
- To master the scientific basis of the molecular techniques allowing the study of the function and interaction of genes and their products to measure molecular activity.

- To gain further insight into the use of genetic transformation to obtain transgenic breeds resistant to diseases and of superior quality, and to assess the advantages and drawbacks of the application of this methodology from a technical and social point of view.
- To be able to integrate these genomic advances in conventional animal breeding programmes to obtain specific objectives and enhance the efficacy of programmes.

Unit 3 **LABORATORY OF MOLECULAR GENETICS (5 ECTS)**
17-30 Nov. '09

Content:
Extraction and quantification of nucleic acids
Electrophoresis of nucleic acids using agarose and acrylamide gels and capillary electrophoresis
DNA amplification
Analysis of amplified products: DNA sequencing
Microsatellite genotyping
SNP genotyping

Learning outcomes:
- To know how to extract DNA and RNA from different types of biological samples.
- To be able to carry out a quantification and a quality analysis of DNA and RNA by capillary electrophoresis or agarose and acrylamide gel electrophoresis, in order to know if the existing quantity and quality in the sample is adequate to carry out subsequent genetic studies.
- To gain practical experience in PCR methodology for DNA amplification and the analysis of amplified products to sequence DNA and carry out the gene functional analysis.
- To gain practical experience in the use of microsatellite markers for genetic studies of linkage and linkage disequilibrium, and to assess its advantages and drawbacks compared with the use of other methodologies.
- To gain practical experience in different methods for detecting simple nucleotide polymorphisms to be used in association studies, as markers in the analysis of quantitative trait genes and in identification tests.

Unit 4 **BIOINFORMATICS PRACTICALS (5 ECTS)**
01-23 Dec. '09

Content:
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

Learning outcomes:
- To know how to use the available on-line tools for the efficient design of PCR primers and their optimization to better obtain PCR products and avoid the formation of false products.
- To become familiar with the different available genomic databases of nucleic acids and proteins.

- To gain experience in the use of the bioinformatic programs BLAST and CLUSTAL to detect similarities between gene sequences and the multiple alignment of sequences, and to know how to use bioinformatic databases to analyse DNA sequences for the determination of genes coding for particular proteins and for intra- and inter-specific genetic comparison.
- To know how to carry out the computer detection of microsatellites used as markers in studies of genetic differentiation and population structure, and to use the computer tools useful in the characterization of patterns for interpreting their functional or structural relationships.
- To be familiar with the existing software to analyse electropherogram images obtained from electrophoresis results.
- To know how to use the computer programs GENEPOP and FSTAT to analyse marker genetic diversity, and PHYLIP to study the molecular phylogenetic relationships.
- To gain experience in the use of computer tools to improve the analysis of gene expression data obtained by DNA microarrays.

Unit 5 **FUNDAMENTALS OF STATISTICAL GENETICS (4 ECTS)**

11-26 Jan. '10

Content:

Introduction to the basic concepts of statistics and matrix calculus
Infinite random mating populations
Mating between relatives
Finite populations

Learning outcomes:

- To update the basis of statistics and matrix calculation relevant to quantitative genetics.
- To know how to determine the genetic structure of a population, to be aware of the changes that can be produced in the population over time, and to know how to calculate the genetic distance between populations.
- To know the effects on genetic variability and inbreeding arising in the medium and long term in finite animal populations, and to be able to apply strategies to limit these effects.

Unit 6 **QUANTITATIVE GENETICS I (5.5 ECTS)**

27 Jan.-
16 Feb. '10

Content:

- 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

Learning outcomes:

- To update knowledge on genetic and environmental effects taking part in phenotype expression, and to value the importance of their interactions.
- To be acquainted with the concepts relative to the different types of gene action: additivity, dominance and epistasis, and their repercussion in animal breeding programmes.
- To be able to use the methodologies to estimate the genetic parameters "repeatability", "heritability" and "genetic correlations", and analyse the implications that these parameter values have in the choice of selection methods.
- To know the different selection methods, to be capable of building selection indices adequate for each one, and to be able to estimate the corresponding expected genetic progress.

Unit 7 **QUANTITATIVE GENETICS II (4 ECTS)**

17 Feb.-
01 Mar. '10

Content:

- 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

Learning outcomes:

- To know the statistical basis and properties of the different methods used in the estimation of additive genetic values, and to gain practical experience in the use of the software developed for the different models.
- To broaden knowledge to detect and use QTL's to locate and identify complex traits of interest for breeding.
- To update the concepts behind the genetic funds of crosses and their interest in livestock production, and to gain experience in the different types of crosses that can be used in breeding programmes, assessing their advantages and drawbacks in each production context.

Unit 8 **QUANTITATIVE GENETICS III (4 ECTS)**

02-15 Mar. '10

Content:

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

Learning outcomes:

- To know how to use the different methods for the estimation of genetic or environmental components of variance in animal populations.
- To adequately apply random regression techniques for linkage analysis and estimation of genetic parameters.
- To know and to be able to use the Bayesian statistical methods and their applications in the estimation of variance components and genetic parameters, and in the prediction of genetic values, as an alternative and complement to traditional methods.
- To be able to plan experimental designs common to animal breeding, and to gain practical experience in the analysis and interpretation of real data coming from such experiments.

Unit 9 **MANAGEMENT AND CONSERVATION OF GENETIC RESOURCES (3 ECTS)**

16-29 Mar. '10

Content:

Decline and conservation of the genetic diversity of domestic animals
Genetic diversity
Genealogical analysis
Population structure
Genetic management in conservation programmes
Marker-assisted conservation
Animal resources conservation in the world

Learning outcomes:

- To be aware of the deterioration in the genetic diversity of livestock, to know the causes and to value the usefulness of maintaining local genetic resources as a fundamental element of sustainable production systems and as a source of genes of interest for specific trait breeding of industrial livestock.
- To be able to apply the basic genetic concepts to characterize and manage the existing resources, and to use molecular information appropriately in order to support this activity.
- To know the main current actions being carried out worldwide to slow down loss of biodiversity and to conserve existing genetic resources.
- To be able to establish and manage sustainable programmes for *in situ* and *ex situ* conservation of livestock genetic resources guaranteeing the active participation of stakeholders.

Unit 10 **BREEDING PROGRAMMES (7 ECTS)**

30 Mar.-
22 Apr. '10

Content:

- Review of current breeding programmes carried out in different countries and institutions to exemplify the different breeding methodologies and technics using an applied approach. Dairy and beef cattle, dairy and meat sheep, goats, pigs, poultry, rabbits and aquaculture species
- The applications of breeding in the case of developing countries
- Technical visits and round table discussions

Learning outcomes:

- To gain experience in the particularities of the main livestock species by means of the analysis of breeding programmes carried out in Spain and other countries.
- To know the different alternatives and strategies that can be applied in breeding programmes, and to critically analyse their advantages and drawbacks in different situations.
- To be able to define and integrate the different components interacting in an animal breeding programme, and to plan its implementation according to the species, the established objectives and the environmental and socioeconomic conditions.
- To exchange ideas with the professionals in charge of the design and management of real breeding programmes.

Unit 11 **REPRODUCTION FUNDAMENTALS AND TECHNIQUES (5 ECTS)**

23 Apr.-
07 May '10

Content:

Bases of reproduction
Semen technology
In vivo oocyte and embryo production
In vitro embryo production
Embryo transfer
Fundamentals of cryobiology
Transgenic embryo production

Learning outcomes:

- To update the anatomical and physiological basis of livestock reproduction and the factors influencing it.
- To review and assess the reproduction methodologies and main techniques increasing the reproductive efficiency of selected individuals, or allowing gamete and cell manipulation for breeding purposes.

Unit 12 **PRACTICALS IN REPRODUCTION TECHNIQUES (3.5 ECTS)**

10-27 May '10

Content:

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

Learning outcomes:

- To gain practical experience in obtaining semen, evaluating its quality and conserving it by freezing.
- To be able to carry out artificial insemination from thawed semen with the needed oestrus synchronization.
- To know how to apply the laboratory techniques for embryo maturation, fertilization and culture to produce *in vitro* embryos.
- To gain practical experience in embryo recovery and freezing.

Unit 13 **REPRODUCTION BIOTECHNOLOGIES PER SPECIE (4 ECTS)**

28 May-
17 June '10

Content:

- Review of current reproduction biotechnology programmes carried out in different institutions. Cattle, sheep, goats, pigs, rabbits and poultry
- Round table discussions
- Technical visits to insemination centres

Learning outcomes:

- To be able to apply the previously acquired knowledge to the main livestock species, considering the reproduction particularities and problems of each one and assessing the biotechnological strategies applicable in each case.
- To gain experience in the evaluation of real applied programmes and in the analysis of their results.
- To exchange ideas with the professionals of the sector directly involved in reproduction biotechnology activities.
- To have first hand knowledge of the infrastructure and facilities of different institutions related to assisted reproduction, and to assess the work they are carrying out.

EXAMINATIONS

Participants take 6 written examination during the course. 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.

LANGUAGE OF INSTRUCTION

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.

ACADEMIC STAFF

Some 40 invited lecturers from 4 countries participate in the M.Sc. programme of which, 55% come from Research Centres, 42.5% from Higher Education Institutions and 2.5% from International Centres.

Part 2
The Master of Science thesis

Project (60 ECTS)

This part is organized in 2 Units

INTRODUCTION TO RESEARCH (30 ECTS)

The aim of this unit is to provide the prior knowledge, skills and attitudes necessary to carry out a research project in a particular topic in the speciality of animal genetics and breeding.

Learning outcomes:

- To improve skills in the search for information, as well as in its selective treatment.
- To develop criteria for defining the objectives of a particular research study.
- To know how to plan the research work in order to best achieve the objectives set and to optimise time.
- To develop skills in the use of techniques and methodologies relevant to the execution of a research project and to discern the advantages and disadvantages of each one for each particular project.
- To know how to integrate knowledge and to learn how to analyse and contrast results.
- To value the guidance received to plan and develop a research work, fostering dialogue, criticism and capacity to work as a member of a team.
- To develop skills for self-directed learning and autonomous work.
- To improve the capacity of response to unforeseen situations and the ability to reorient a research if need be.

MASTER THESIS (30 ECTS)

The aim of this unit is to apply previous education received throughout the Master programme to carry out original research in the topic chosen in the previous unit, that concludes with the elaboration of a written thesis.

Learning outcomes:

- To be able to apply previously acquainted knowledge, methods and techniques in a discerning manner.
- To develop skills in the analysis of problems and in the definition of objectives.
- To know how to design the diverse experiments included in the research project correctly.
- To be competent in data collection and analysis according to a pre-established research protocol.
- To gain experience in the analysis of results and the elaboration of conclusions that may contribute to clarify and find a possible solution to problems.
- To develop skills in the synthesis and presentation of contents and in the preparation of scientific texts.0
- To gain practice in the preparation and presentation of oral communications and in their public defence.
- To acquire attitudes to favour exchange and collaboration with other researchers and professionals.

Research work is carried out in 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.

The assessment of acquired competences for both units is made by an examining board composed of representatives of the organizing institutions and external members selected in each case for their expertise and prestige in the field of the research work. For the first unit, this assessment is based on: (i) an oral examination by the examining board; (ii) the evaluation done by the thesis director on the performance of the candidate; and (iii) the evaluation based on the reports presented periodically by the participant, with the support of the thesis director, on the development and progress of the research work. For the second unit, assessment is based on quality of the thesis and on its public presentation and defence.

Research activities: most common topics for Master of Science theses

- Estimation of genetic parameters
- Breeding values of production and quality traits of specific breeds
- Genetic characterization of breeds and populations
- Analysis of molecular markers of interesting traits
- Semen quality and conservation
- In vitro embryo culture

INDICATIVE MASTER THESES REALIZED WITHIN THE AREA

1. **Title**: Molecular analysis of the goat lipoprotein lipase and acetyl-coenzyme A carboxylase α-genes (2006)
   Author: Bouabid Badaoui, Agronomist, Moroccan
   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
2. **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, Lebanese
   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
3. **Title**: Genetic polymorphism in goats. Study of the beta-lactoglobulin, the kappa casein, and stearoyl coenzyme A desaturase genes (2000)
   Author: Habib Yahyaoui, Agronomist, Tunisian
   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
4. **Title**: Identification of type I and II genetic markers in the genome of animals of livestock interest (1997)
   Author: Carmela Senese, Agronomist, Italian
   Place of realization: Dipartimento di Scienze delle Produzioni Animali, Facoltà di Agraria, Università degli Studi della Basilicata, Potenza, Italy
   Thesis director: Piero Masina

Detailed additional information is available at
http://www.iamz.ciheam.org/en/pages/paginas/pag_formacion8.htm