International Master in

ANIMAL BREEDING AND REPRODUCTION BIOTECHNOLOGY

PROGRAMME

MODULE I

UNIT 1: MOLECULAR GENETICS

Autonomous University of Barcelona

1.1. Molecular bases of animal genetics (5 ECTs) (35 L)

1.1.1. Basic concepts of animal genetics (0.5 ECTs)
M. Amills. UAB. Barcelona

1.1.2. Organization and structure of the eukaryotic genome (0.5 ECTs)
M. Amills. UAB. Barcelona

1.1.3. Control of gene expression in eukaryotes (1 ECTs)
M. Amills. UAB. Barcelona

1.1.4. Molecular techniques to study variability (2.5 ECTs)
A. Sánchez. UAB. Barcelona

1.1.5. Genetic markers (0.5 ECTs)
M. Ballester. IRTA. Barcelona

1.2. Animal genomics (5 ECTs) (35 L)

1.2.1. Structural genomics (2.5 ECTs)
JM. Folch. UAB. Barcelona. **M. Amills**. UAB. Barcelona
- 1.2.1.1. Genetic maps
- 1.2.1.2. Comparative mapping
- 1.2.1.3. Gene identification
- 1.2.1.4. Genome sequencing: strategies and results

1.2.2. Functional genomics: (2.5 ECTs)
M. Pérez-Enciso. ICREA-UAB. Barcelona. **B. Amorena**. CSIC-UPNA. Pamplona. **A. Sánchez**. UAB. Barcelona.
- 1.2.2.1. General techniques in the studies of gene function
- 1.2.2.2. Microarrays
- 1.2.2.3. Proteome analysis
- 1.2.2.4. Mutation-independent techniques
- 1.2.2.5. Molecular bases for disease resistance
- 1.2.2.6. Animal transgenics and genome modifications

1.3. Laboratory of molecular genetics (5 ECTs) (35 P)

M. Ballester. IRTA. Barcelona. **O. Vidal**. Univ. Girona. **A. Sánchez** UAB. Barcelona. **JM. Folch**. UAB. Barcelona

1.3.1. Extraction and quantification of nucleic acids (DNA and RNA) from different types of biological samples. Electrophoresis of nucleic acids in azarose and acrylamide gels, and capillary electrophoresis

1.3.2. DNA amplification. Conventional PCR. RT-PCR and quantitative PCR

1.3.3. Analysis of amplified products: DNA sequencing

1.3.4. Microsatellite genotyping

1.3.5. SNP genotyping: RFLPs. *Primer extension analysis. SNPlex, pyrosequencing,* allelic discrimination using *Taqman* probes

1.4. Bioinformatics practicals (5 ECTs) (35 P)

M. Amills. UAB. Barcelona. **JM. Folch,** UAB. Barcelona. **O. Vidal**. Univ. Girona. **M. Pérez-Enciso**. ICREA-UAB. Barcelona. **S. Ramos**. ICREA-UAB. Barcelona

1.4.1. Design and optimization of PCR primers

1.4.2. Use of databases (DNA and proteins)

1.4.3. Sequence alignment (BLAST. CLUSTAL)

1.4.4. Interpreting sequencing results: sequence analysis

1.4.5. Microsatellite analysis: interpreting patterns

1.4.6. Solving electropherogram interpretation problems

1.4.7. Use of software packages to analyse genetic markers (GENEPOP. FSTAT)

1.4.8. Molecular phylogeny (PHYLIP)

1.4.9. Analysis of gene expression data obtained from microarrays

UNIT 2: APPLIED BREEDING
Polytechnic University of Valencia

2. APPLIED BREEDING (27.5 ECTs) (105 horas: 52.5 L + 52.5 P)

2.1. Fundamentals of statistical genetics (4 ECTs) (12 L + 12 P)
A. Blasco. UPV. Valencia

2.1.1. Basic concepts of statistics (2 ECTs)
2.1.1.1. Descriptive statistics and statistical parameters
- Mean, median, mode, variance, standard deviation, range, variation coefficient
- Standardization. Covariance, correlation, variance from the mean, covariance with one mean
- Regression, coefficient of determination

2.1.1.2. Measuring uncertainty and testing the hypothesis
- Standard error, confidence interval, confidence interval for difference between means
- Hypothesis test: significance, experimental design

2.1.1.3. Linear models
- The general linear model. Minimum squares. Matrix products, meaning of X'X with one effect? Meaning with two effECTs, meaning of X'Y, invertible matrices, arbitrary restrictions and estimable functions

2.1.2. Population genetics (2 ECTs)
2.1.2.1. Genetic structure of a population
- The gene of molecular genetics and the gene of population genetics
- Equilibrium with one locus
- Equilibrium with two loci. Consequences of disequilibrium in a selection programme

2.1.2.2. Changes in population gene frequencies
- Selection
- Mutation. Long-term importance
- Migration. Importing alleles in a breeding programme
- Genetic drift. Loss of alleles in small populations

2.1.2.3. Inbreeding and kinship
- Kinship coefficient and inbreeding coefficient
- Inbreeding and heterosis
- Effect of inbreeding on genotype frequencies
- Effect of inbreeding on the mean of a trait
- Control of inbreeding

2.2. Quantitative genetics I (5.5 ECTs) (16.5 L + 16.5 P)

2.2.1. Variation and types of gene action (3.5 ECTs)
M.A. Santacreu. UPV. Valencia
2.2.1.1. Continuous variation
- Introduction
- Genotype x environment interaction

- Environmental effECTs
- Maternal effECTs
- Concept of repeatability
- Estimation of repeatability

2.2.1.2. Gene effECTs
- Concept of additivity. Dominance and epistasis
- Additive and dominant values
- Average effect of a gene, additive value and breeding value
- Breakdown of genotypic value with several genes.

2.2.1.3. Heritability
- Definition
- Heritability of the mean of several means
- Using heritability to predict the additive value of an individual
- Estimation of heritability: covariance between relatives.

2.2.1.4. Threshold traits
- Concept
- The observable scale and the underlying scale
- Heritabilities on both scales

2.2.1.5. Genetic correlation
- Introduction
- Relationship between phenotypic, genetic and environmental correlation
- Covariance between relatives for two traits
- Estimating genetic correlation

2.2.2. Basic concepts and types of selection by additive value (2 ECTs)
N. **Ibáñez** UPV. Valencia

2.2.2.1. Individual selection
- Introduction
- Selection pressure, selection intensity, selection differential
- Predicting response to selection
- Generation interval and response per unit of time
- Generation interval and response to selection in overlapping generations
- Experimental evaluation of selection theory
- Evaluation of response

2.2.2.2. Predicting additive value
- Individual selection and prediction of additive value
- Prediction by regression in a general context
- Standard error and confidence interval of prediction
- Prediction precision
- Selection index for a single trait

2.2.2.3. Selection methods
- Selection by the mean of various controls
- Indirect selection. Correlated response
- Selection by partial control
- Family selection
- Intrafamily selection
- Selection by relatives, progeny test

2.2.2.4. Joint selection of several traits
- Selection index with individual information
- Tandem selection
- Selection by independent levels
- Comparison between methods

2.3. Quantitative genetics II (4 ECTs) (18 L + 18 P**)**

2.3.1. Mixed linear model (4 ECTs)
N. Ibáñez. UPV. Valencia

2.3.1.1. Linear models
- Introduction
- Factors and variables
- Fixed and random factors
- The model

2.3.1.2. Estimation
- Properties of an estimator
- Deduction
- Estimability

2.3.1.3. Prediction
- BLUP: deduction. Variance in predictors and variance in prediction error
- Mixed model equations: variance of predictors and prediction errors and resolution algorithms

2.3.1.4. The animal model
- The model and the mixed model equations
- Kinship. A and A^{-1} matrices. Factorization of A and calculation of A^{-1} ignoring inbreeding

2.3.1.5. The problem of the base population
- The animal model with genetic groups
- Equations of the model

2.3.1.6. Other animal models
- Repeatability
- Common environmental effECTs
- Maternal effECTs

2.3.1.7. Multivariate animal models
- Definition. Precision and selection bias
- Traits with similar or different design
- Traits measured in different relatives

2.3.2. Detection and use of QTLs (0.5 ECTs)
N. Ibáñez UPV. Valencia

2.3.2.1. Detection
- Linkage analysis
- Statistical aspECTs

2.3.2.2. Use
- Gene introgression
- Marker assisted selection

2.3.3. Crossbreeding (0.5 ECTs)
N. Iáñez. UPV. Valencia

2.3.3.1. Taking advantage of non-additive genetic variance
- Inbreeding depression
- Heterosis
- General and specific combining ability
- Selection for improving crossbreeding: Recurrent selection. Recurrent reciprocal selection

2.3.3.2. Crossbreeding in animal production
- Interest of crossbreeding in livestock production
- Two-way, three-way or four-way crosses. Selection of the lines used in crossbreeding

- Rotation crossing
- Comparison between crosses
- Use of specialized lines

2.4. Quantitative genetics III (4 ECTs) (12 L + 12 P)

2.4.1. Estimation of variance components by REML (0.4 ECTs)
A. Blasco. UPV. Valencia
2.4.1.1. Variance components in the mixed model
2.4.1.2. REML to estimate the variance of a normal population
2.4.1.3. Estimation of variance components using the VCE program

2.4.2. Random regression (0.1 ECTs)
A. Blasco. UPV. Valencia

2.4.3. Bayesian estimation (3.5 ECTs)
A. Blasco. UPV. Valencia
2.4.3.1. Introduction to Bayesian inference
2.4.3.2. MCMC and Gibbs sampling
2.4.3.3. Estimation of the mean and the variance in a simple model
2.4.3.4. Estimation of genetic values and variance components
2.4.3.5. Genomic selection

2.5. Management and conservation of genetic resources (ECTs) (12 L + 4P)
B. Villanueva (Polytechnic University of Madrid)
2.5.1. The importance of genetic resource conservation
2.5.2. Genetic diversity
2.5.2.1 Inbreeding, kinship and effective size
2.5.2.2 Genealogical and molecular measurements of inbreeding and kinship
2.5.3. Genetic management of conservation programmes
2.5.4 Genetic management of selection programmes
2.5.5 Applications (examples): Indicators of genetic diversity, Iberian pig, Atlantic salmon

2.6. Breeding programmes (7 ECTs) (63 L + 21 P)

2.6.1. Beef cattle
M.J. Carabaño (INIA. adrid)

2.6.2. Dairy cattle
R. Cantet (UAB. Argentina)

2.6.3. Dairy sheep
E. Ugarte (Neiker. Vitoria)

2.6.4. Beef sheep
M. Serrano (INIA. Madrid)

2.6.5. Goat
E. Gómez (CITA-IVIA. Valencia)

2.6.6. Pigs
B. Nielsen (SEGAS, Dinamarca)

2.6.7. Poultry
J. Arango (Logman. EEUU) y S. Avendaño (Aviagen, United Kingdom)

2.6.8. Rabbits
M.A. Santacreu (UPV. Valencia)

2.6.9. Aquaculture
A. Sonneson (Nofima, Norway)

2.6.10. Breeding applications in developing countries
A. Haile(ICARDA, Lebanon)

2.6.11. Technical visits

UNIT 3: REPRODUCTION BIOTECHNOLOGY
Polytechnic University of Valencia

3. REPRODUCTION BIOTECHNOLOGY (12.5 ECTs) (117 horas: 71 L + 46 P)

3.1. Reproduction fundamentals and techniques (5 ECTs) (42 L)

3.1.1. Bases of reproduction (1 ECTs)

E. Mocé, M.P. Viudes (CITA-IVIA. Valencia), **F.Forcada** y **J. Yáñiz**. (Univ. Zaragoza)

- 3.1.1.1. Reproduction endocrinology
- 3.1.1.2. Spermatogenesis
- 3.1.1.3. Oogenesis and folliculogenesis. Oestrus cycle
- 3.1.1.4. Fertilization. Embryo development. Pregnancy and parturition
- 3.1.1.5. Factors that influence reproduction
- 3.1.1.6. Reproduction pathology

3.1.2. Reproduction techniques (4 ECTs)

E. Mocé. M.P. Viudes (CITA-IVIA. Valencia), **A. Gutiérrez** (INIA. Madrid) y **J.S. Vicente** (UPV. Valencia)

- 3.1.2.1. Semen technology
  - -Recovery
  - -Quality evaluation techniques
  - -Conservation methods
  - -Sperm sexing
- 3.1.2.2. In vivo production of oocytes and embryos
  - -Superovulation treatments
  - -OPU (Ovum Pick-Up)
  - -Laparoscopy
- 3.1.2.3. In vitro embryo production
  - -In vitro maturation
  - -In vitro fertilization. Intracytoplasmatic injection (ICSI)
  - -In vitro embryo culture
  - -Embryo quality evaluation
- 3.1.2.4. Embryo transfer
- 3.1.2.5. Fundamentals of cryobiology: cryoconservation of oocytes and embryos
- 3.1.2.6. Transgenic embryo production. Microinjection. ICSI and somatic cloning

3.2. Practicals in reproduction techniques (3.5 ECTs) (32 P)

J.S. Vicente y **F. Marco** (UPV. Valencia)

3.2.1. Recovery. Semen valuation and freezing (0.9 ECTs)

3.2.2. Thawing. Synchronization and AI (0.9ECTs)

3.2.3. In vitro embryo production: IVM. IVF. EC (0.9ECTs)

3.2.4. Embryo recovery. Freezing (0.8ECTs)

3.3. Reproduction biotechnologies per specie (4 ECTs) (29 L + 14 P)

3.3.1. Cattle
D. Rizos (INIA. Madrid)

3.3.2. Sheep
E. Mocé (CITA-IVIA. Valencia)

3.3.3. Goats
M.P. Viudes (CITA-IVIA. Valencia)

3.3.4. Pigs
J. Roca y M.A. Gil (Univ. Murcia)

3.3.5. Rabbits
J.S. Vicente (UPV. Valencia)

3.3.6. Poultry
E. Blesbois (INRA. Tours, France)

3.3.7. Round tables
- 3.3.7.1. Establishment and management of germplasm banks and health control
- 3.3.7.2. Current status of semen conservation and AI
- 3.3.7.3. Challenges for embryo production. Conservation and ET

3.3.8. Technical visits to research and insemination centres

MODULE II

UNIT 4: PRINCIPLES AND TECHNIQUES ASSOCIATED WITH RESEARCH

Research centre associated with the Master

4. **PRINCIPLES AND TECHNIQUES ASSOCIATED WITH RESEARCH** (30 ECTs)

   4.1. **Initiation to scientific research** (10 ECTs)

   4.2. **Techniques and data analysis** (10 ECTs)

   4.3. **Scientific documentation** (10 ECTs)

UNIT 5: MASTER OF SCIENCE THESIS

Research centre associated with the Master

5. **MASTER THESIS** (30 ECTs)