Quantitative Genetics and Improving

Code: 101960
ECTS Credits: 6

2025/2026

Degree	Type	Year
Genetics	OB	3

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Teaching groups languages

You can view this information at the end of this document.

Prerequisites

- To know the fundamental concepts of Mendelian and Population Genetics, Biostatistics and Genomics.
- To be able to read scientific texts in English.
- To be able to use the basic informatic tools.

Objectives and Contextualisation

Quantitative genetics addresses the genetic analysis of quantitative or complex traits, such as some of the involved in the evolution of species, the ones determining most of the productive traits in plants and animals, and also the predisposition to diseases. Its most applicative side has been, and continues to be, the genetic selection, that is made to improve plant and animal production.

There is a phenomenon clearly observable, the resemblance between relatives, for which Quantitative Genetics has developed a model based upon previous concepts of Population genetics. This model assumes that complex traits are determined by a large number of genes. By applying several statistical concepts it is possible to estimate a number of genetic parameters that will inform if the trait is susceptible to be selected. All this theory is based in classic papers from Fisher, Wright, Lush and others.

In addition to selection that is done within populations, crossing among populations is a strategy widely used to improve production traits. This course covers both the theoretical and applicative aspects of both methodological approaches, and also the population structures that make the genetic improvement more efficient.

On the other hand, in the last years there has been a growing interest regarding the identification of particular genes that determine quantitative or complex traits. Currently we have different molecular genetics tools that allow us to genotype a high number of SNP (single nucleotide polymorphism) loci that are markers for quantitative trait loci (QTL) dispersed across the genome. This strategy of identification is known as "Genome wide association studies". This course covers the explanation of this strategy and another related strategy such as genomic prediction.

The specific learning objectives are:

- To understand a model explaining the variability of complex traits and become familiar with different methodologies used to measurethe degree of resemblance between relatives.
- To develop evaluation methods of candidates to selection and to understand the factors determining selection response in different selection strategies.
- To know the implications of the different mating systems.
- To became familiar with the current methods for detecting genes affecting complex traits and their application in the context of medicine and genetic improvement.
- To know examples of improvement programs in animals and plants.

Competences

- Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
- Apply knowledge of theory to practice.
- Apply scientific method to problem solving.
- Describe and interpret the principles of the transmission of genetic information across generations.
- Design and interpret studies associating genetic polymorphisms and phenotypical characters to identify genetic variants that affect the phenotype, including those associated to pathologies and those that confer susceptibility to human illnesses or those of other species of interest.
- Design experiments and interpret the results.
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Measure and interpret the genetic variation in and between populations from a clinical, conservational and evolutionary perspective, and from that of the genetic improvement of animals and plants.
- Perceive the strategic, industrial and economic importance of genetics and genomics to life sciences, health and society.
- Produce, direct, execute and assess projects where knowledge of genetics or genomics is necessary.
- Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
- Take sex- or gender-based inequalities into consideration when operating within one's own area of knowledge.

Learning Outcomes

1. Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
2. Apply knowledge of theory to practice.
3. Apply scientific method to problem solving.
4. Apply statistical technologies and methodologies to genotype/phenotype association studies.
5. Design experiments and interpret the results.

6. Enumerate and describe the forces that modulate genetic variation in populations in isolation or in conjunction.
7. Estimate the genetic parameters of a character from crossbreeding.
8. Evaluate the economic interest in genetically improving livestock species.
9. Evaluate the importance of having a map of correspondences between genotype and phenotype variation as the basis for selecting new livestock varieties and creating personalised drugs and foods.
10. Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
11. Produce and assess genetic improvement projects.
12. Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
13. Take sex- or gender-based inequalities into consideration when operating within one's own area of knowledge.

Content

Unit 1. Quantitative Genetics and its application to the analysis of complex traits and selection.
Unit 2. The infinitesimal model in quantitative/complex traits.
Unit 3. Estimation of variance components in ANOVA designs. Repeatability.
Unit 4. Detection of QTL: association studies ("Genome-wide association studies").
Unit 5. Resemblance between relatives.
Unit 6. Heritability and genetic correlations: estimation methods.
Unit 7. Genetic evaluation: Selection indices, BLUP and genomic prediction.
Unit 8. Response to the selection and factors that determine it.
Unit 9. Inbreeding depression.
Unit 10. Genetic improvement in plants.
Unit 11. Genetic improvement in pigs.
Unit 12. Genetic improvement in ruminants.
Unit 13. Genetic resistance to diseases.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	30	1.2	3, 2, 4, 9, 8, 5, 11, 6, 7
Problems lab	15	0.6	3, 5, 11, 6, 7
Type: Supervised			
Tutorials	5	0.2	3, 2, 4, 9, 8, 5, 11, 6, 7
Type: Autonomous			
Individual study and self learning	45.5	1.82	
Problem solving and exercise DCBSP	42	1.68	12, 3, 2, 8, 5, 11, 6, 7

The teaching methodology that will be used throughout the learning process is fundamentally based on the work of the students, and the teacher will be in charge of helping them both in terms of the acquisition and

interpretation of information related to the subject and in the direction of their work. In accordance with the teaching objectives of the subject, the training activities that will be carried out are:

Theoretical classes: With these classes, students acquire the fundamental knowledge of the subject, which will be worked on and complemented in problem classes, tutorials and practices in a computerized classroom. These will be interactive master classes in which dialogue with students will be encouraged and will be based on audiovisual materials, mainly ppt presentations, which will be posted in advance on the Virtual Campus.

Problem classes: They will be carried out in two small groups of about 30 participants. They will consist of problem solving, which will help them to reason in the context of Quantitative Genetics and to understand the fundamental concepts of the subject. There will be problems that will be solved in class and others that the students will have to solve on their own. It is assumed that all problems will be worked on beforehand by the students before going to class.

Self-learning - Work will be carried out with the Dairy Cattle Breeding Simulation Program (DCBSP) that allows to become familiar with the genetic and genomic selection of dairy cattle through an approach based on simulation. Students will also solve the problemes before the resolution is explained in the classroom.

Practices in the informatic classroom: Formally they are included in the subject of Integrated Laboratory V, but in fact they are an essential complement to better understand everything that has been explained in theory classes.

Tutorials: Arranged sessions to solve doubts andhold discussions on specific contents of the subject and problems.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Mid-term exam 1	35%	1.5	0.06	1, 13, 12, 3, 2, 4, 9, 8, 5, 6, 7, 10
Mid-term exam 2	35%	1.5	0.06	1, 13, 12, 3, 2, 4, 9, 8, 5, 11, 6, 7, 10
Practical work with the Dairy Cattle Breeding Simulation Program (DCBSP) software	30%	8	0.32	1, 13, 12, 3, 2, 8, 11, 10
Retake exam	70%	1.5	0.06	1, 13, 12, 3, 2, 4, 9, 8, 5, 11, 6, 7, 10

The evaluation will be individual and will be carried out continuously in the context of the different training activities that have been scheduled.

There will be 2 theoretical-practical midterm exams, through a multiple-choice test. These tests will include theory questions and problems. They will last 90 minutes. The results of the theoretical-practical tests will account for 70% of the final grade (35% each midterm).

There will also be a work with the Dairy Cattle Breeding Simulation Program (DCBSP) software that will account for 30% of the final grade.

The minimum final grade to pass the subject will be 5 points out of a maximum of 10 points. This final grade will be calculated as a weighted average of the grades of the two midterms and the exercise with DCBPS. To average, the grades of the two midterms must be equal to or greater than 4.5, while a minimum grade will not be required for the work. To pass the subject, the average of the 2 midterms (or the final exam) must be equal to or greater than 5. Under the conditions indicated by the professor responsible for the subject, the final grade may be raised depending on the attitude, the degree of academic achievement and, above all, the student's participation in the activities carried out in class.

In the event that the subject is not passed through this continuous assessment, students will be able to recover one or both midterms in the corresponding recovery test. To participate in the reassessment, students must have been previously evaluated in a set of activities whose weight is equivalent to a minimum of 2/3 of the total grade of the subject. Therefore, students will obtain the grade of "Not Assessed" when the evaluation activities carried out have a weighting below the threshold indicated above. Students who want to raise their grade can do so on the day of theRetake Exam. In this case, the grade that will be taken into account to calculate the final grade will be the one obtained in the retake test. The work will not be recoverable.

SINGLE ASSESSMENT: Students subjected to single assessment will take a Final Exam that will cover all the subject (theory and problems) on the day that the Partial 2 is held, and in case of failure they will be able to recover on the day of the Recovery Exam. The Final Exam will represent 100% of the final grade.

Review of grades: both in single and continuous assessment, the teacher will inform the students of the day/time/place of the review of the tasks submitted for evaluation.

Bibliography

General

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Falconer D.S., Mackay T.F.C. 2001. *Introducción a la Genética Cuantitativa.* Acribia, Zaragoza.

Lynch M., Walsh B. 1997. *Genetics and analysis of quantitative traits*. Sinauer, Sunderland.

Walsh B., Lynch M. 2018. *Evolution and selection of quantitative traits*. Sinauer, New York.

Animals

Blasco A. 2021. *Mejora genética animal*. Síntesis, Madrid.

Minvielle F. 1990. *Principes d'amélioration génétique des animaux domestiques.* INRA, Paris.

Nicholas F.W. 2003. *An introduction to Veterinary Genetics*. Blackwell Publishing, Oxford.

Piedrafita J. 1998. *Notas sobre teoría de mejora genética.* Col·lecció Materials, 49. Servei de Publicacions UAB, Bellaterra.

Plants

Acquaah G. 2012. *Principles of Plant Genetics and Breeding*, 2nd Ed. Wiley, Wiley-Blackwell. (on-line in UAB)

Allard R.W. 1999. *Principles of plant breeding*. Wiley, New York.

Cubero J.I. 2013. *Introducción a la Mejora Genética Vegetal*. 3a ed. Mundi-Prensa, Madrid.

Kang M.S. 2002. *Quantitative genetics, genomics and plant breeding*. CABI, Wallingford. (on-line in UAB; there is a new edition from 2020)

Rodríguez Borruezo A. 2009. *A primer of Genetics and Plant Breeding*. UPV, Servicio de Publicación, Valencia.

Software

Simulation study:

DCBSP: https://www.casellas.info/software.html

Web sites (for Lab Integrat V):

Genup: http://www-personal.une.edu.au/~bkinghor/genup.htm

PQGen: https://sites.google.com/a/unizar.es/pqgen/

PLINK: http://pngu.mgh.harvard.edu/~purcell/plink/

R: http://cran.r-project.org/

Groups and Languages

Please note that this information is provisional until 30 November 2025. You can check it through this link. To consult the language you will need to enter the CODE of the subject.

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	631	Catalan	first semester	morning-mixed
(PAUL) Classroom practices	632	Catalan	first semester	morning-mixed
(TE) Theory	63	Catalan	first semester	morning-mixed