Universitat Autònoma de Barcelona

2023/2024

Quantitative Genetics and Breeding

Code: 101960
ECTS Credits: 6

Degree	Type	Year	Semester
2500890 Genetics	OB	3	1

Contact

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Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject.
Please note that this information is provisional until 30 November 2023.

Teachers

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Jordi Garcia Mas

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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.

Methodology

The teaching methodology used along the learning process will be based upon the student's work, and the teacher will be in charge of helping the student in acquiring and interpreting the information related to the contents of the subject.

According to this methodology, the activities that are the following:

Lectures: Lectures will address the fundamental knowledge of the subject. Lectures will be interactive and will foment the dialog with and among students. They will be based on audiovisuals (mainly ppt presentations) that will be uploaded into Campus Virtual before the lectures. This activity will be complemented with classes devoted to solving problems, tutorial sessions and practical sessions in the computer laboratory.

Problems seminars: There will be 2 groups of about 30 students each. The seminars will consist of solving problems in an active manner. This will help the reasoning in the context of Quantitative Genetics and the understanding of the fundamental concepts of the subject. There will be problems solved in the classroom and others that the student will have to solve by him/her self. It is assumed that all the problems will be worked out by the students prior to the seminar.

Self learning and study group: In addition to solving problems in the classroom, groups of 2 different students will have to solve 3 exercises representing the most important items of the course.

Computer practices: Formally they are included in the course "Laboratori Integrat V", but they are a great support to better understand what has been taught in the lectures.

Tutorials: Concerted sessions to solve doubts discuss specific contents of the course.

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.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lectures	30	1.2	3, 2, 4, 8, 9, 5, 11, 6, 7
Problems lab	15	0.6	3, 5, 11, 6, 7
Type: Supervised			
Tutorials	5	0.2	3, 2, 4, 8, 9, 5, 11, 6, 7
Type: Autonomous			
Individual study and self learning	55	2.2	
Problem solving	42	1.68	3, 2, 5, 6, 7

Assessment

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

There will be 2 theoretical-practical partial exams, through a test-type exam. These tests will include theory questions and problems. They will last 90 minutes. The results of the theoretical-practical tests will account for 80% of the final grade (40% for each partial).

In order to verify that the students progress in understanding the problems, 3 exercises must be handed in during the course. These exercises will be done in groups of 2 students and, once assessed, will account for 20% 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 partials and exercises. To calculate this average, each grade must be equal to or higher than 4. Similarly, a minimum grade of 4 must be obtained in each exercise to make an average. The final grade may be enhanced based on the student's attitude, academic achievement and, above all, their 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 partials in the corresponding recovery test. To take part in the recovery, students must have previously been assessed in a set of activities whose weight is equivalent to a minimum of two-thirds of the total grade of the subject or module. Therefore, the student will obtain the qualification of "Not Assessable" when the assessment activities carried out have a weighting of less than 67% in the final qualification. This

recovery test, similar to the one described for the partials, will consist of 40 questions if both partials are recovered, or 25 questions if one of the partials is recovered. This approach will be applicable to students who want to improve their grades. In this case, the grade that will be taken into account to calculate the final grade will be the one obtained in the recovery test.

UNIQUE EVALUATION: Students subjected to a unique evaluation will be examined on the entire subject on the day that partial 2 is held, and in case of failing, they will be able to take a recovery exam on the same day as their classmates. The final exam will account for 90% of the final grade. The other 10% of the grade will be determined by the delivery of a solved problem.

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

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Mid-term exam 1	40%	1.5	0.06	1, 13, 12, 3, 2, 4, 8, 9, 5, 11, 6, 7, 10
Mid-term exam 2	40%	1.5	0.06	1, 13, 12, 3, 2, 4, 8, 9, 5, 6, 7, 10
Problem solving in groups	20%	0	0	1, 13, 12, 3, 2, 4, 8, 9, 5, 11, 6, 7, 10
Recovery exam (theory and problems)	0	0	0	1, 13, 12, 3, 2, 4, 9, 6, 7, 10

Bibliography

General

Caballero A. 2017. *Genética Cuantitativa*. Síntesis, Madrid.

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

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/