MSc specialization Animal Breeding and Genetics at Wageningen University

The MSc specialization "**Animal Breeding and Genetics**" focuses on the development and transfer of knowledge in the area of selection and breeding of animals that have a function for humans in food production, company, recreation, or nature conservation.

Animal breeding has increasingly become an integrated, worldwide industry. In recent years the emphasis on animal biodiversity has been growing. This has had an impact on livestock, especially in relation to sustainability. The courses in this specialisation focus on the genetic improvement of farm and companion animals by integrating quantitative, biological and molecular approaches. DNA techniques are emphasised because they are increasingly being used to determine genetic diversity in animal populations and as tools in selective breeding. All courses focus on disciplinary knowledge with illustrations of applications in livestock, companion animals, and captive wild life populations.

Education

ABGC has chosen for a specific and deliberate strategy for their education, in which they divide the courses they offer in two profiles. These profiles are: "*Animal breeding*" and "*genomics*"

Students in Animal Breeding and Genetics can choose between these two profiles which each consist of a series of two compulsory[1] and one or more free choice courses.

For the profile *animal breeding,* the compulsory courses are **Genetic Improvement of Livestock (GIL)**, in combination with either **Modern Statistics for the Life Sciences (MSLS)** or **Population and Quantitative Genetics (PQG).** Students are advised to have followed the pre-master course **Animal Breeding and Genetics (ABG).**

For the profile *genomics,* the compulsory courses are **Genomics**, in combination with **Population and Quantitative genetics (PQG),**r **Modern Statistics for the Life Sciences (MSLS), Advanced Bioinformatics (AdvBio), or Genetic Analyses Tools and Concepts (GATC).** Students with a strong interest in application of Genomics to livestock animals are also advised to follow one or more courses from the MSc specialization "Bioinformatics".

First, a short description of these courses is given below. Extensive information on these courses is available on the internet Next, we discuss the scheduling of these courses in the academic year.

Courses provided by ABG

Animal Breeding and Genetics (ABG-20306; BSc, pre-master level): This course deals with the basic principles of Animal Breeding and Genetics. The course assumes only prior knowledge on basic genetic principles like Mendelian inheritance, Locus, Alleles. Topics that are dealt with are: genetic relationships, genetic models, breeding value estimation, breeding programs, inbreeding, dominance and crossbreeding, estimating genetic gain, linkage and QTL analysis. These principles are explained using examples from farm and domestic animals, rare breeds and zoo populations. The course consists of lectures, computer practicals and group assignments. This course is given in period 1, afternoon, by teachers from the Animal Breeding and Genomics centre.

[1] Strictly speaking, these courses are not compulsory but "restricted optionals": recommended courses that prepare for the specialization. In practice, students will always do these courses.

Genetic Improvement of Livestock (ABG-31306; MSc, advanced): This course builds on the premaster course **Animal Breeding and Genetics** and explains how genetic merit from animals can be estimated. The course offers an in-depth treatment of mixed model equations to estimate unbiased breeding values. Other chapters deal with estimation of genetic correlations, derivation of economic values and breeding goal definition. A large part of the course is devoted to the design of breeding programs for production and health traits, and to the maintenance of genetic variation in breeding populations. Applications in practice are explained by guest speakers from professional breeding organizations. The course consists of lectures and practicals in which students learn how to solve, with the use of various computer programs, predefined " cases".

GIL is given in period 2, morning, by teachers from the Animal Breeding and Genomics centre and is seen as the core course for the profile "animal breeding".

Genomics (ABG30306; MSc, advanced): In this course students learn how genomic information is obtained, analyzed and utilized. The course discusses the structure and function of genomes of living organisms from all kingdoms. The topics that are treated cover: molecular markers; linkage maps; fluorescent in situ hybridization; chromosome structure and topology; whole genome sequence analysis; whole genome comparison; genome synteny and evolution; expression analysis by micro-array techniques;- proteomics; hapmap projects and functional genome analysis by random and targeted mutagenesis.

The course consists of 12 individual modules that each are comprised of the following activities: (1) Introductory lecture outlining the principles of the methodology and giving an overview of the current state of that particular subject using examples from the recent literature (2) Computer practical of 5-8 hours during which students use recent genomics data that are available at a variety of databases that are accessible through a web interface (3) groups of students present the results from the exercise by using a PowerPoint presentation.

Genomics is given in period 2 and period 5 in the afternoon, by teachers from Animal breeding and Genetics, from Phytopathology and from Microbiology. The course is compulsory for students Cell and Molecular Biology, Bioinformatics, and Plant biotechnology. The course is a restricted optional for students in Plant Sciences, Animal Breeding and Genetics, (Plant)-Biotechnology, and (Molecular) Biology.

Genetic Analysis Tools & Concepts (MSc, advanced): this course explains how genetic analysis is used to unravel and understand biological phenomena, such as aging, adaptation, symbiosis, somatic incompatibility, and sexual reproduction.. For each of these subjects appropriate approaches of genetic analysis are presented. They provide the student with an understanding of genetic recombination, mutation and genetic transmission of genes in prokaryotes and eukaryotes. The organization of chromatin and chromosomes is studied as well as the analysis of genomes. Main Learning outcomes are:

- have thorough understanding of the concepts of genetic transmission;
- understand genetic recombination, both at the chromosomal and molecular level;
- be able to judge the consequences of mutations and recombination;
- comprehend the common strategies of genetic analysis;
- understand genetic dissection;
- be able to perform genetic experiments and to analyze experimental data;

The course **Genomics** assumes basic knowledge on molecular biology and genetics. For ABG students, two courses are of relevance here: the BSc course **Gene Technology**, and **Genetic Analysis, Tools and Concepts (GATC)**. A brief description is given in the intermezzo below.

Intermezzo: "preparing for genomics"

Gene technology (MOB-20306, period 1, afternoon): this course focuses on four major topics: (i) production of transgenic mammals, (ii) disrupting gene functions using knockouts and RNAi, (iii) transgenic mice as human model systems and (iv) production of transgenic crops. Conventional lectures outline the major procedures, applications and some research papers. The practical course involves a set of basic biomolecular techniques, including construction of a small genomic DNA library, site-directed mutagenesis, PCR, and hybridisation analysis. These experiments are carried out in a virtual environment (the simple cloning lab).

Learning outcomes:

- to understand methods currently used to clone, analyze and manipulate genes and to introduce foreign genes into animals and plants;
- to design experimental strategies and interpret experimental data involving gene technology;
- to apply basic recombinant DNA techniques, to interpret the results of these experiments involving these techniques, and to incorporate the results in a written report;
- to apply basic regulations when working with genetically modified micro-organisms.

Modern Statistics for the Life Sciences (ABG-30806; MSc, advanced): In this course students learn to develop statistical models and to apply these to a large diversity of biological datasets. The first part of the course deals with statistical topics: maximum likelihood, mixed models, generalized linear models and Bayesian statistics. The second part deals with an in-depth treatment of genetic parameter estimation, QTL mapping, and Epidemiology. The course consists of lectures, practicals and the statistical analysis of two cases.

The course is given in period 5, afternoon, by teachers from Animal breeding and genetics, from Plant breeding and from Mathematics.

Population and Quantitative Genetics (Gen-30806; MSc, introductory): This course introduces principles of population and quantitative genetics, building on basic knowledge obtained in the courses **Fundamentals of Genetics and Molecular Biology** (***Gen-11806***). The course explains the phenotypic, genetic and molecular evolution of populations under natural and artificial selection. Topics covered are: genetic variation, the Hardy-Weinberg principle, and the evolution of gene frequency; multi-locus genetics and linkage disequilibrium; the effects of mutation, selection, drift, migration and inbreeding in relation to the population structure; polygenic inheritance, heritability, and the evolution of quantitative traits; genotype by environment interaction and environmental sensitivity; conservation genetics and the genetic management of small populations; and the interpretation of results from genetic analyses of populations.

This course is given in period 6, week 35-39, by teachers from 4 chairgroups "Genetics", "Plant Breeding", "Resource Ecology" and "Animal Breeding and Genetics". This is a relatively new course, which was first given in 2006/7. Introduction of the course was motivated by the rapid developments in molecular technology, making large-scale population genetics data available for many species. This course uses the book "A primer of population genetics" by Daniel L. Hartl. The lectures follow the book.

Other courses

Ecology of Life Histories (ABG-50806). This course focuses on the key concepts needed to understand the evolution of life histories. Specific topics include: life history trade-offs (in the wild and in animals selected for production); optimality and game theory models; physiological mechanisms underlying trade-offs; mechanisms underlying plasticity in life histories; sexual selection and animal communication; animal personalities. The emphasis of the course is on understanding concepts and learning how to design experiments. Students are expected to play an active role and there is ample time for discussions and problem

solving exercises. Teaching consists of a mixture of lectures/discussions and work by the students.

This course is given in period 4 by researchers from the Netherlands Institute of Ecological Research (NIOO, Wageningen). The number of students is restricted to around 15-20. All students are evaluated on the basis of an oral exam and a written report.

Course scheduling

Courses are scheduled in such a way that students can follow the profile courses in "the right order". A student starting in period one of the academic year, will follow Animal Breeding and Genetics, followed by Genetic Improvement of Livestock or Genomics in period 2. Modern Statistics for the Life Sciences is given in period 5, and Population and Quantitative Genetics in period 6. They can start with their (major) thesis in period 3 or do additional courses. This general track is somewhat different for the different groups of students of ABGC.

General learning track MAS students Animal Breeding and Genetics

	Period 1 (sept-oct)	Period 2 (nov- dec)	Period 3 (jan)	Period 4 (feb)	Period 5 (mar-apr)	Period 6 (may-jul)
morning		GIL/ AdvBio				PQG wk 35-39 full time GATC wk 40-43 full time
afternoon	ABG GATC	Genomics*			Genomics* /MSLS	

*(optional in period 1 OR 2)

Regular MAS(BDW) students that enter the MSc are assumed to have followed ABG. They often choose courses from other specializations e.g. "Health and Welfare Management", or "Animal Nutrition" in period 1, to complement their MAS training.

For international (not EM-ABG) and HBO students the choice of courses is somewhat limited. These students should follow the course "**Scientific skills training (YMC-61303)**" in period 1 (morning). We recommend that these students also take the pre-master course **Animal Breeding and Genetics**, as a preparation for their profile choice. Another frequently recommended course, that aims at filling a knowledge gap in statistics is the BSc course "**Advanced statistics (MAT-20306; period 1 or 2, morning or afternoon)**".

Intermezzo: advanced statistics

Advanced statistics builds on this knowledge and contains: Multiple linear regression; Factorial designs; Two-way analysis of variance: additive and interaction models, F-tests for interaction and/or main effects, t-tests for one parameter or a linear combinations of parameters; Chi-Square tests for (count) data summarized in a contingency table.

After these courses the student should be able to:
- given a research question/hypothesis: make a plan (type of design or sampling procedure) for data collection.
- given a data set from a known experiment or sample: analyze the data (choice of method, carry it out in SPSS, discuss the results and conclusions);
- given the results/conclusions from an experiment with the analysis of the data: understand the details of the analysis, evaluate/criticize the data collection procedure, and the analysis.

Below are two examples of typical learning tracks for each profile *Animal breeding* and *Genomics* for international and HBO MAS students.

Animal Breeding

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
morning	**SST**	**GIL**	thesis	thesis	thesis	**(PQG)**
afternoon	***ABG***	***Advanced Statistics***			**MSLS**	Thesis

Genomics

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6
morning	**SST**	***Advanced statistics/AdvBio***	Thesis	Thesis	Thesis	**PQG**
afternoon	**ABG**	**Genomics**			(**MSLS**)	GATC

Of course it is possible for *Animal Breeding* students to follow courses like Genomics and MSLS. Likewise, students who do the *Genomics* profile can also follow GIL.

Version August 2015, ABGC
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