SYLLABUS – SECOND SEMESTER (M1S2)

Master Biodiversity, Ecology and Evolution

International Pathway "Evolutionary Biology"

COURSE TITLE: From genotype to phenotype (Virginie Cuvillier, Associate Professor)

NUMBER of ECTS: 3
Number of hours: **Lectures: 17.5h**, **Tutorials: 8h**
Personal workload (hours expected to be dedicated to, including supervised projects): **46,5 hours**

Description of the module

General aims
Better apprehend biological systems complexity and their diversity.
Acquire global knowledge about molecular and physiological processes that contribute to phenotypic diversity.
Combine knowledge from different scientific domains (molecular and cellular biology, physiology, ecophysiology) to better understand phenotypic variation.

Content summary
- Genetic regulatory networks: regulation of genetic expression; genetic interactions
- Perception of the variable environment: cellular and molecular consequences
- Integrative biology of organisms: physiological regulatory networks (PRNs) and their applied applications

Expected knowledge and skills:
To be able to integrate concepts and knowledge from molecular, cellular and organismal biology
To be able to understand scientific articles, perform critical analysis and oral presentation

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam	**60%**
Continuous assessment (oral)	**40%**

COURSE TITLE: Theoretical modeling (Sylvain Billiard, Associate Professor)

NUMBER of ECTS: 3
Number of hours: **Lectures/Tutorials: 18h**
Personal workload (hours expected to be dedicated to, including supervised projects): **54 hours**

Description of the module

General aims
Be able to translate an evolutionary or ecological problem into a model in order to address a specific question or make predictions.

Content summary
- Stochastic models of evolutionary and ecological dynamics, and their approximations
- Numerical analysis, algorithmic and computer simulations of a stochastic model
- Comparison between data and models prediction
- Inference of biological parameters with a process-based model

Expected knowledge and skills:
Direct abilities:
- Modeling a specific problem
- Analyzing a deterministic dynamical system (ODE, stability analysis)
- Writing a stochastic models and approximating invasion probability
Indirect abilities:
- Mathematical training
- Programming for simulations and numerical analysis of a model

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam (Oral presentation of the analysis of a simple model)	**100%**

COURSE TITLE: Ecology: from theory to experiments (Anne Duputié, Associate Professor)

NUMBER of ECTS: 3
Number of hours: **Lectures: 11h**, **Practicals: 16h**
Personal workload (hours expected to be dedicated to, including supervised projects): **45 hours**

Description of the module

General aims
The course is designed to provide an overview of the theoretical and applied aspects of ecology, with a special emphasis on species' geographic distributions in a changing world. The course includes a project work, in which students will design an experiment and/or plan field work, perform this field work or short experimental project, analyze and interpret their data and write a short report.

Content summary
Lectures:
- How to measure fitness?
- How are life-history traits connected to species' geographic distributions?
- How and at what pace do life-history traits evolve?
- Contemporary evolution in a changing world
- Species interactions in relation to environmental gradients
- Assessing biodiversity using metabarcoding approach

Practicals: Students will lead a project in small groups. For example, they could assess how climate change can affect species' phenology and geographic distribution (through designing experiments aiming at calibrating phenological models for common plant species). Alternatively, they could assess how intra and interspecific interactions vary along an environmental gradient (e.g., pollution gradient). Or, they could estimate biodiversity in samples from different environmental conditions, using a metabarcoding approach. In either case, students will be expected to perform a bibliographic search, to design their protocol, perform the experiment, analyze their data and write an individual report.

Expected knowledge and skills:
Direct:
- based on examples, understand how environmental constraints drive local adaptation and species assemblages.
- design a realistic yet scientifically valid protocol
- perform field work and an experiment in the field of ecology

Indirect:
- work in a small team
- perform an efficient bibliographic search
- mobilize the knowledge acquired in biostatistics and R programming language to analyse data
- write a report in English

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam (Oral presentation)	**50%**

Continuous assessment (design a protocol, carry out experiments, Report)	**50%**

COURSE TITLE: Experimental approaches in Ecology (Isabelle De Cauwer, Associate Professor)

NUMBER of ECTS: 3
Number of hours: **Lectures: 7h**, **Practicals: 20h**
Personal workload (hours expected to be dedicated to, including supervised projects): **45 hours**

Description of the module

General aims
- Formulating a scientific question in ecology and identifying relevant hypotheses,
- Designing an experimental protocol to tackle a question in ecology, while taking into account the logistic / biological constraints,
- Choosing and implementing appropriate statistical analysis with regard to the scientific question.

Content summary
At the beginning of the term, students will get tutorials on experimental design, data set manipulation and statistical analysis. Each student will then be assigned a scientific question in ecology and will create an experimental protocol to tackle that question. Finally, students will receive a real-life data set corresponding to the initial scientific question and will analyze it using statistical tools.

Expected knowledge and skills:
Direct skills:
- Manipulating data sets in ecology (formatting, producing graphic outputs, carrying out statistical analysis) with various software programs (Excel and R).

Indirect skills:
- Presenting a scientific reasoning, both in synthetic written documents and in oral presentations,
- Developing a critical sense by evaluating the relevance of experimental protocols and statistical analysis carried out by their peers.

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam (oral presentation)	**50%**
Continuous assessment (small report)	**50%**

COURSE TITLE: Analysis of empirical population genetics data (Isabelle De Cauwer, Associate Professor).

NUMBER of ECTS: 3
Number of hours: **Lectures: 2h**, **Practicals: 25h**
Personal workload (hours expected to be dedicated to, including supervised projects): **45 hours**

Description of the module

General aims:
- Describing the intra (genotypic structure) and inter-population genetic structure using basic genetic data : the number of alleles, the allelic richness, the observed heterozygosity, the expected heterozygosity.
- Depicting the levels of genetic differentiation among populations using *F*-statistics.
- Learning how to describe the spatial genetic structure using spatial autocorrelation tools at both intra and inter population level.
- Analyzing contemporary dispersal events through the detection of migrants from first generation using assignment tests.

Content summary
Based on the practical courses, students have to analyze a real population genetics data set and present the obtained results through a final oral defense. Depending on the academic year, the data set to be analyzed might be:

- A data set including spatially structured populations of the land snail *Helix aspersa* (*Cornu aspersum*) sampled along a roadside in Britanny (Western France) and genotyped using both allozymes and microsatellite loci.
- A data set including a set of populations of the invasive shore crabs *Hemigrapsus sanguineus*, located along the coastline of north-western France and genotyped using microsatellite loci.
- A data set of 4 populations of the sea beet (*Beta vulgaris* ssp. *maritima*), located along French and Swedish coastlines, and genotyped using microsatellite loci.
- A data set of populations of a pioneering Amphibian species (*Pelodytes punctatus*) located in a post-industrial fragmented habitat in northern France, and genotyped using microsatellite loci.

Expected knowledge and skills:
- Getting an overview of molecular markers commonly used in molecular ecology.
- Using various software programs to describe the levels of genetic diversity in wild populations and estimate *F*-statistics.
- Understanding the notion of migration-drift equilibrium using neutral genetic markers.
- Understanding the statistical tools for performing one and two-dimensional spatial autocorrelation analyses using univariate or multivariate approaches.
- Presenting a synthetic scientific reasoning through an oral presentation.

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam (oral report in front of a jury)	**100%**

COURSE TITLE: Multivariate statistics (Catherine Crônier, Professor)

NUMBER of ECTS: 3
Number of hours: **Lectures: 3h**, **Practicals: 6h**, **Tutorials: 3h**
Personal workload (hours expected to be dedicated to, including supervised projects): **60 hours**

Description of the module
General aims:
Students will get an introduction into multivariate data analysis and its application to problems in biology and paleontology.

Content summary
- Introduction: matrices, distributions, variance, covariance
- Data reduction: ordination and clustering methods
- Discrimination and classification
- Multivariate hypothesis testing
- Application of multivariate data analysis in biology and paleontology

Expected knowledge and skills:
- Knowledge on various ways to analyze multivariate datasets, and therewith on how to use multivariate statistics to test hypotheses in biology and paleontology
- Formulating hypotheses and interpreting results
- Communicating methods and results

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Continuous assessment (data analysis, report)	**100%**

COURSE TITLE: Research in "Global Changes & Biodiversity" (Anne Duputié, Associate Professor)

NUMBER of ECTS: 3
Number of hours: **Tutorials: 12h**
Personal workload (hours expected to be dedicated to, including supervised projects): **60 hours**

Description of the module

General aims:
This course will be based on seminars given by a panel of researchers active in the field of ecology and evolutionary ecology, especially in the context of global change.

Content summary
1. Interspecific interactions along environmental gradients
2. Geographic range limits and range shifts
3. Tolerance to pollutants

Expected knowledge and skills:
Integrative biology; Ecology; Evolutionary Ecology; Theoretical modeling; Biostatistics

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Continuous assessment (peer reviewing of recently posted preprints on BiorXiv)	**100%**

COURSE TITLE: 2 months Internship (Isabelle De Cauwer, Associate Professor)

NUMBER of ECTS: 9
Number of hours: 280h

EVALUATION MODE (final exam, oral defense, report,...)	Ratio of the final grade
Final exam (written report, oral defense)	**100%**