UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Animals Biological Interactions

2526-1-F0602Q120

Aims

All living organisms interact with other organisms throughout their entire lifespan. In extreme cases, such as intracellular symbioses, the habitat of one organism is another living being. The study of these interactions involves the integration of various biological disciplines, including zoology, genetics, physiology, ecology, microbiology, and bioinformatics. Understanding the nature and fine mechanisms of these interactions is a major challenge in basic science, with numerous applied implications ranging from biodiversity and ecosystem conservation to the characterization of microbial communities that influence human health or drive key biotransformation processes of natural resources.

1. Knowledge and Understanding:
   By the end of the course, students will have acquired knowledge of different levels of complexity in interactions involving animals—from those with unicellular symbionts to those with the environment (e.g., ecosystem services). This will be achieved through classroom presentations and critical discussions of real-world case studies related to the course topics. Topics will also include behavioral manipulation of animal hosts resulting from interactions with other organisms.

2. Applying Knowledge and Understanding:
   Students will be able to apply the knowledge acquired (as described in point 1) to research contexts such as thesis work or related subjects. This will be supported by in-class debates and targeted questions during the final assessment.

3. Making Judgments:
   Students will be expected to critically evaluate the content learned and select the most appropriate approach to connect functional characteristics of animal organisms to broader levels of interaction, such as ecosystem services. This ability will be assessed during the final exam through the presentation of a bibliographically sourced case study, with explicit focus on identifying critical aspects of the selected research.

4. Communication Skills:

By the end of the course, students will be able to clearly and accurately describe various types of animal interactions and their evolutionary and applied implications (e.g., bioprospecting, ecosystem services). This will be evaluated through the personal reworking (e.g., via PowerPoint presentation) of a real-world case study drawn from the scientific literature (see point 3).

5. Learning Skills:
   Students will develop the necessary skills to independently pursue further studies requiring knowledge of symbiosis, molecular identification of organisms, and inter-species interactions. They will also be able to connect and integrate this knowledge with concepts acquired in future courses. This will be assessed through specific questions aimed at stimulating a "scientific debate" during the final exam.

Contents

The course aims at discussing the study of biological interactions involving animal species under an integrative and multilevel approach. There are many possible ways to treat these topics. In this course, provided in the framework of our master program, it will be offered a wide overview concerning the principal kinds of interactions, including their evolutionary and functional aspects. Specific attention will be devoted to the application of animals' biological interactions in terms of conservation, management of natural resources and bioprospecting.

Detailed program

General aspects of animals' interactions
• Definition and importance of biological interactions
• Functional diversity and interaction diversity
• Interaction networks
• Why study animals' biological interactions?
o Theoretical aspects (metanalyses)
o Ecosystem services
o Conservation biology issues (extinction of species vs. extinction of interactions)
o Human health (bioprospecting)
o Social and economic issues
• The diversity of animals' interactions
o The multilevel characterization of animal interactions

A focus on symbioses
• Definitions (symbiosis, host, symbiont)
• Historical aspects
• Classification of interactions
o Antagonistic interactions
o Mutualistic interactions
o Consumption interactions
o Competitive interaction (amensalism, allelopathy, antibiosis)
• Framing the interactions (exploitation competition, apparent competition)
• Types of symbiosis (and examples)
o Commensalism
o Amensalism
o Inquilinism
o Phoresy

o Parasitism and parasitoids
• Indirect effects of mutualism
• The problem of classifying symbiotic interactions
• Sexual parasitism
• How context-dependent are species interactions?

The challenge of identification
• Why do we need to identify the “interactors”?
• Limitations of classical identification approaches
• Is species identification challenging?
• Molecular identification (target and untarget DNA-based approaches)
o DNA barcoding
* Integrative taxonomic concepts (MOTUs, IOTUs, UCSs, DCLs, CCSs)
o DNA metabarcoding
* Environmental DNA
* DNA metabarcoding to identify animal interactions
* Modern applications of eDNA
o Metagenomics
o Metatranscriptomics

Intracellular symbioses
• Definitions and context
• The domains of life (Archaea, Bacteria, Eucarya)
• The endosymbiotic origin of eukaryotes
o Endosymbiosis (historical aspects)
o The Serial Endosymbiosis Theory (SET)
* Which supports to the SET (case studies and other biological aspects)
* Undulipodia
* Set chronology
o The origin of mitochondria
* Mitochondrial early theory
* Mitochondrial late theory
* Syntrophic hypothesis
o The origin of plastids
o The origin of other organelles (peroxisomes)
o The origin of the nucleus
* Chimeric origin
* Viral origin
• The original host (new theories)

Insects – bacteria interactions
• General aspects
o Primary and secondary symbionts
* Bacteriocytes, co-phylogeny, genome shrinkage
* Vertical vs. horizontal transmission
• Why insects need intracellular symbiotic bacteria?
• Case study: Aphids and Buchnera
• Case study: pseudococcidae and bacteria
• Other case studies on sap-feeding insects: Bemisia tabaci
• Stolen genes & nutritional interactions
o The Horizontal Gene Transfer
o Case studies
• Other intracellular symbioses in insects
o Camponotus ants and Blochmannia
o Cockroaches and Blattabacterium

• Hematophagous insects
o Case study: Glossina flies and Wigglesworthia / Sodalis

Other intracellular nutritional interactions
• Case study: Olavius algarvensis
• Case study: Bathymodiolus molluscs
• Case study: Riftia pachyptila
• Case study: Osedax mucofloris

Sacoglossa and kleptoplasty interactions

Wolbachia
• Historical aspects
• Effects and transmission of Wolbachia in filarioid nematodes and arthropods
• Origin, occurrence and diversification of Wolbachia
o Wolbachia supergroups
* Phylogenetic assessment of supergroups and problems
* The enigma of supergroup F
• The manipulation of genetic diversity and sex-ratio in insects mediated by Wolbachia
o Cytoplasmatic incompatibility
* Unidirectional vs. bidirectional
* Wolbachia infection and species delimitation in insects
* Case study: Ischnura spp.
* Case study: Andrena spp.
o Induced parthenogenesis
o Male-killing effect
o Genetic males feminization
o Multi-potent effects
o Positive effects
o True Parasitism
• Wolbachia: Lateral gene transfer to eukaryotes hosts
• Aside Wolbachia: the Torix bacteria

Bioluminescence interactions
• Definition and base concepts
• The mechanisms of bioluminescence
o Horizontal Gene Transfer
o Diet
o Symbiosis
• Case study: Euprymna scolopes and Vibrio fischeri
o Vibrio fischeri colonization mechanism and timing
o Modification in E. scolopes induced by V. fischeri
o Modification of V. fischeri after the colonization
o Regulation mechanisms of the interaction
o The induction of bioluminescence
• Other bioluminescent symbiotic bacteria

Pollination
• Pollination ecology: single species and complex networks
• investigating the impact of anthropogenic stressors on pollinator insects
• Connections between pollinators health and human health: a nutritional perspective

Seed dispersal
• Background and importance
• The plant “point of view”

o Seed Dispersal Effectiveness
o Seed Rain
o Study cases
• The disperser “point of view”
• Seed dispersal and migration
o The frugivory paradox
o The geographic scale of seed dispersal
* Short-ranged dispersal
* Long distance dispersal
• How to study seed dispersal
o Case studies
• Global drivers of seed dispersal
o Defaunation
o Invasive species
• Seed dispersal and restoration

Host manipulation by parasites
• Background and relevance in the context of animal interactions
o The “hitch-hiking” hypothesis
o Positive effects of manipulation on the host
• Historical aspects
• Evolutionary aspects
o Manipulation sensu stricto
o Facultative virulence: mafia-like strategy
o Exploitation of compensatory responses
o The evolution of manipulation after its emergence
• Adaptative significance of host manipulation
• Mechanisms behind host’s behavior manipulation
o Case study: Toxoplasma gondii
o Case study: Neuroviruses
o Case study: Gammarids and Acanthocephalans
o Case study: Suicidal crickets
o Case study: Bodyguard manipulation
o Case studies: Fungi and “Zombie” insects
o Case Study: the extreme autotomy in Sacoglossan molluscs
o A possible role of host/parasite microbiomes?
• Manipulation of plant phenotype
o Background and relevance
o Manipulation mediated by herbivores
* Shelter-building herbivores
* Canal cutting insects
* Green islands-inducing insects
o Manipulation of plant-pollinator interactions
• Visual trickery in avian brood parasites
o Case study: Cuculus canorus
o Case study: the widow birds
• Brood care host manipulation
• Social host manipulation

SEMINARS:

Prerequisites

Microbiology, Zoology, basic knowledge of cell biology and molecular biology.

Teaching form

Lectures in the classroom. Some lessons could be seminars hold by experts in the sectors discussed during the course.

- 21 lessons (2 hours each) held in presence

Textbook and teaching resource

Scientific articles provided by the teacher during lessons. Students can obtain them by accessing to the electronic library of the University. The slides of classoroom lessons and seminars will be available on the elearning Platform.

Semester

First semester

Assessment method

The verification of the knowledge aquired during the course will consist in an oral examination at the end of the course. The examination will start with the critique discussion of a scientific article chosen by the student (and previously approved by the teacher), concerning the general issues treated in the lessons. The examination will continue with the discussion of the arguments included in the program of the course.

There will be not intermediate tests.

Office hours

Upon request by email (andrea.galimberti@unimib.it)

Sustainable Development Goals

LIFE ON LAND