

COURSE SYLLABUS

Animals Biological Interactions

2425-1-F0601Q120

Aims

All living beings interact with other organisms during their life's cycle. In extreme cases such as intracellular symbioses, habitat could act as another organism. The study of these interactions is conducted by integrating different sources of biological information (zoology, genetics, physiology, ecology, microbiology, bioinformatics). Understanding characteristics and the mechanisms involved in such biological interactions is challenging in a context of base science. This kind of investigation also has many applicative outcomes ranging from biodiversity and ecosystems conservation to the characterization of microbial communities. Microbiomes influence human health and allows the principal activities of biotransformation of natural resources. 1) knowledge and understanding: At the end of the course, the student will have acquired knowledge regarding the different levels of complexity of interactions in the animal context, from those involving microbial organisms to those with the environment. Moreover, topics related to the host behavior manipulation mediated by interaction with other organisms will be discussed. 2) Applying knowledge and understanding: At the end of the course, the student will be able to apply the knowledge acquired during the course to other courses or thesis programs involving the issue of animal interactions. 3) Making judgements: The student will be able to critically adopt the acquired knowledge and choose the most reliable approach to link the functional traits of organisms to their possible complex interactions, for example in a context of ecosystem services. 4) Communication skills: At the end of the course, the student will be able to describe clearly, and with an adequate language the different types of interactions and their effects in terms of evolutionary aspects and applied contexts (e.g., bioprospecting). 5) Learning skills: At the end of the course, the student will have the necessary knowledge to deal with the next studies that will require knowledge of symbioses, molecular identification of organisms and their interactions. Finally, the student will be able to associate and integrate the acquired knowledge with the concepts belonging to the successive courses.

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 Cytoplasmic 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 held 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 classroom lessons and seminars will be available on the elearning Platform.

Semester

First semester

Assessment method

The verification of the knowledge acquired 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
