Parasitology
BIOL 3403

Syllabus

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• Lecture: 11:00-11:50 MWF WSB 101
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  – Or 3-5:00pm, Monday FOX 131

Do Parasites Rule the World?

• Traditionally, only considered to be protists, worms, and arthropods.
• Now known to encompass everything from protists up to the diversity of metazoans.
• One of the most common lifestyles in existence, with an estimate 1/3 of life being parasitic (Price 1980).
• In fact, of the 35 animal phyla, only echinoderms, chordates, and a few minor phyla do not have representative parasitic members.
Organismal Associations?

- Any association more or less permanent is called a symbiosis, with each member a symbiont.
- Commensalism – one benefits while the other is neither harmed nor helped.
  - Epiphytes like orchids and bromeliads
- Mutualism – both benefits from the relationship.
  - Lichens being a union of algae and fungi
- Predation – one benefits while another is killed
  - Primitive relation in which one must hunt, kill, and hunt again.
- Parasitism – one benefits while another is harmed.
  - The extent of this “harm” is a topic we will address over the semester.

A simple view

- In a straightforward situation – a small organism (Parasite) has the potential to harm a larger organism (Host), and relies on said host for nutrients and shelter (a Niche). The parasite generally has a much higher reproductive capability compared to its host.

- Unfortunately, parasitism is seldom this clear cut.

Parasites or not?

- If an animal lives inside another, but is not actively causing harm, is it a parasite?

- If an animal temporarily feeds upon another, but leaves its prey alive, is it a parasite?

- If an animal lays its eggs in another, and the young consume the host from the inside-out, is it a parasite?
Parasitic Range

- **Endoparasite vs Ectoparasite**
  - Living inside or outside the host
    - What about *Pneumonyssus simicola* that infest nasal passages and lungs?
- **Temporary vs Permanent**
  - Only on host to feed or only off the host to disperse
- **Obligate vs Facultative**
  - Must have the host to complete life cycle or free-living organism capable of infesting a host under the right conditions.

Life Cycles

- **Direct life cycle**
  - Transmitted from one host to another through the air, by a fomite, or in contaminated food or water.
- **Indirect life cycles** require a vector or intermediate host to reproduce or grow in.

Vectors

- An invertebrate that transmits a parasite from one vertebrate to another.
  - Mechanical vector – no parasitic development of reproduction occurs
  - Biological vector – parasitic reproduction takes place

Many of the protozoan and platyhelminthes require vectors for life cycle completion.
Types of hosts

- Intermediate host
  - Host in which asexual development and growth occur
- Definitive host
  - Host in which sexual development and reproduction occurs
    - In trematodes (flukes), the intermediate host is a snail and the definitive is a vertebrate.
- Phoretic or Transport host
  - Host used for transportation only.
    - Glycyphagid mites on rodents

Epidemiology

- The study of the patterns of diseases within populations
- For parasites, this includes:
  - Host range – what can it infest?
  - Geographic range – where is it?
  - Is it a zoonotic agent?
    - Can it infect humans?
  - Does it have a reservoir?
    - A group of vertebrates maintaining the parasite
  - Does it have a nidus?
    - A small ecosystem it lives possesses all the factors to maintain the parasite.
Evolution of Parasitism

• Parasites have not degenerated into existence.
• Highly evolved specialized organisms capable of using a unique resource and niche.
• Some organisms have evolved between the lines of mutualism and parasitism.
  – *Trypanosoma musculi* and *T. cruzi*
• Others may have been predators that became so specialized as to be parasites.

Evolutionary Arms Race

• Some host-parasite systems seems to show evidence of a co-evolved arms race
• As a parasite evolves better ways to avoid detection and reproduce…
• A host will evolve better means to detect a parasite and remove it.
• Typically ends in a draw.
  – Each gets better to counter the others advantage

Who’s in Charge?

From Zimmer (2000), a crustacean parasite converts its crab host into a castrated, mindless slave. The parasite’s egg sacs are formed where the crab’s own eggs would be, so the crab faithful grooms and “gives birth” to a hoard of little *Sacculina* for the next generation.
Ecology of Parasitism

- Parasites view the host as a landscape to be colonized
- Typically not randomly distributed among available hosts. Overdispersal helps to maintain the host species, which is needed for survival.

Reproduction

- Normally R-selected organisms
  - Produce large numbers of offspring within a short time, and provide those young little to no care.
- Alternation of generation is common
  - Have a sexual life stage in one host and an asexual stage in a vector.
  - Ex. Digenean trematodes

FYI: Most tapeworms have combined asexual and sexual by developing both sex organs within each body segment!

Parasitic Wonders

- Life cycles can be very complex, using numerous hosts and existing in a multitude of environments.
- Parasites move between hosts and the “outside” as needed, which requires different abilities and different forms.
- Most cycles are indeed cyclic, only going forward without the ability to return to an earlier stage.
Host Responses

Nonspecific immunity
- Macrophage endocytosis
  - Common for bacteria and small protozoa
- Inflammation
  - Acute – edema and increase of leukocytes
  - Subacute – monocytes and lymphocytes present, with fibrocytes binding parasite with collagen
  - Chronic – plasma cells present and form a granuloma
- Hyperplasia – parasite causes host to produce more cells
  - Liver fluke simulating enlargement of bile duct
- Neoplasia (cancer) – rare parasites have been associated with cancer, but mechanisms are still unknown.

Host Responses

Specific Immunity
- Humeral response: Formation of antibodies or immunoglobulins (Ig) by B cells.
  - IgE fights helminths
  - IgM and IgG important against protozoans
- Cell mediated response: uses T-cells
  - Cytotoxic T cells inject invading parasites
- Also release cytokines, which promote nonspecific immunity. (interconnected)

Parasite Responses
- Antigenic variation
  - Change surface glycoproteins regularly
- Being poorly antigenetic
  - Don’t induce a response, or a most a mild one
- Hide within host cells
  - Host can’t kill what it can’t find
- Camouflage
  - Use bits of host cells and attach to parasite’s surface
- Depress host’s immune response
  - Modulate produce of host T cell production
How can Parasites be Controlled?

- Toxicants
- Reduce populations of reservoir hosts or vectors
- Induce immunity
- Modify the environment by physically changing it
- Avoid areas of high risk
- Create a quarantine or barrier
- Biological control
- Genetically alter the host
- Separate host age classes
- Testing hosts and removal of infected members

Control

- Toxicants
  - Use of drugs, insecticides, and chemical to kill parasites or reservoir hosts.
  - Quinine was first popular, now many more exist (antibiotics, antihelmintics, etc.)
- Reduce populations of reservoir hosts or vectors
  - Kill off animals that are responsible for transmitting zoonotic agents (spraying mosquitoes)
- Immunity
  - Use of a vaccine containing a live agent, or part of an agent, can induce immunity and prevent future infection.
  - Used to protect population more than individual (Most diseases will not be spread if 80% of population is protected, although some like malaria require 99%.)
- Modify the environment
  - Removal of garbage reduced flies, while draining standing water reduces mosquitoes.
- Avoid Areas of High Risk
  - Keep away from areas of known vectors when they are seasonally abundant.
- Quarantine and Barriers
  - Hold animals until it can be determined they are uninfected.
  - Don’t allow infected hosts into an area cleared of a parasite.
  - Create strips of habitat parasites can not cross
  - Also can apply toward physical barriers – bed nets.
  - Zooprophylaxis – keep animals near to people so vectors feed on them and not us.
Control

• Biological control
  – Use of other organisms to control/eat a parasite or vector.
• Genetic alteration of host
  – Some natural immunity exists to particular diseases, and for parasites to their control drugs.
• Limited success has been made in artificially doing this – sterile male screwworm.
• Separate age classes
  – Keep extremely young potential hosts away from older individuals that may be carriers.
  – Allow the young to mix with others when they can benefit from limited exposure help to induce immunity.

Control

• Test and Remove
  – Whenever a host is tested as being positive for a parasite, it is removed from the population and killed.
  – Used in the control of Mad Cow Disease.
• Needless to say, this is not an approved method of human parasitic infections.

How are Parasites Studied?

• Need to be familiar with invertebrate and vertebrate zoology
• Taxonomy and systematics
• Histology and cytology
• Immunology
• Molecular biology
• Vector Biology and the study of life cycles
Our Focus in Parasitology

- Learn the taxonomic groups of parasites
- Recognize life cycles for important parasites
- Identify diseases associated with particular parasites, and how to recognize them
- Learn about host-parasite relationships and responses
- Discuss epidemiology and control for important parasitic diseases.