Watersheds: Aquatic BioDiversity and Ecology

From an insects perspective

Goal

- Provide background to heterogeneous group of students so you can better understand the papers you have read for tonight and will discuss immediately following this presentation.

Outline

- Define Watershed
- What is BioDiversity
- Diversity of Insects
- Introduction to the Ecology of Aquatic insects

Watershed
Catchment, Drainage Basin

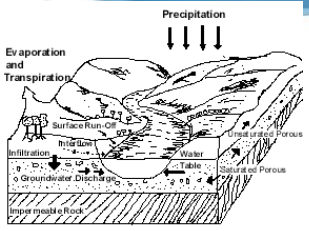


Diagram of various pathways of water after arrival in a typical watershed

- "Watershed" is the term used to describe the geographic area of land that drains water to a shared destination.
- Composed of smaller catchments.

A Stream and its Valley

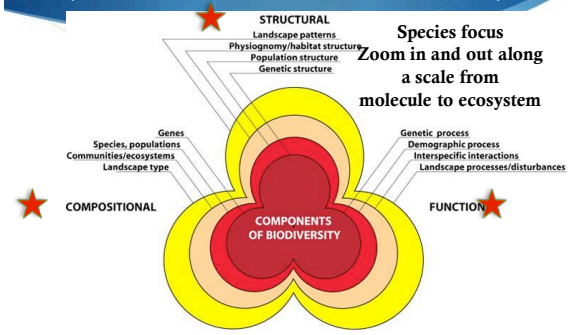
We may conclude then that in every respect the valley rules the stream. Its rock determines the availability of ions, its soil, its clay, even its slope. The soil and climate determine the vegetation, and the vegetation rules the supply of organic matter. The organic matter reacts with the soil to control the release of ions, and the ions, particularly nitrate and phosphate, control the decay of the litter, and hence lie right at the root of the food cycle.

H.B.N. Hynes

Biodiversity

- Discussed *ad nauseum*
- Definition I will use tonight will be the variety of all forms of life from genus to species through to the broad scale of ecosystems (Faith 2007)

Components of Biodiversity
(Noss 1990 modified from Franklin 1988)



Modified from Steinbeck 1941. On describing collection methods:

In most cases … collecting is done by men who specialize in one or more groups.

Thus, one man interested in hydroids will move out on a reef, and if his interest is sharp enough, he will not even see other life forms about him.

For him, the sponge is something in the way of his hydroids.

Collecting large numbers of animals presents an entirely different aspect and makes one see an entirely different picture ….. If you take your time and reflect on the parts you will emerge with a sense of the whole.

Class Insecta

- Class Insecta
  - ~ 1 million insect species.
    - 29 Orders
  - ~ 60 – 70 % of all eukaryotic species (Based on an est. 1.5 – 1.74 eukaryote)
  - Creditable estimates of 3 – 8 million insect species unknown to science.

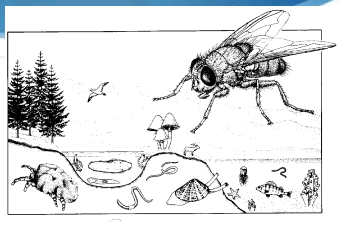
Example of an insect classification

Kingdom … Animalia
Phylum … Arthropoda
Class … Insecta (Hexapoda)
Order … Ephemeroptera
Family … Baetidae
Genus … Barbaetis
Species … benfieldi
Author … Kennedy

To a rough approximation and setting aside vertebrate chauvinism, it can be said that essentially all animals are insects

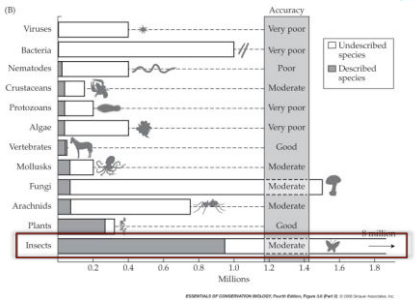
Sir R. M. May 1988

Compare to other groups

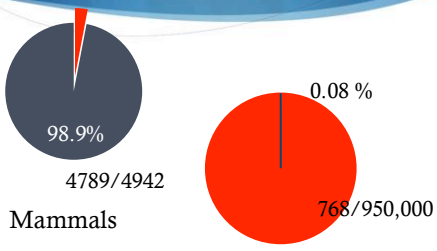


- 4,004 mammals
- 9,020 birds
- 18,818 fish
- 255,000 plants
- 70,000 fungi (could go as high as 1.6 million)

Percent of described versus estimated undescribed species

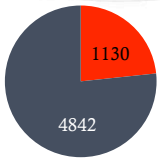


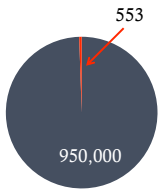
Number evaluated as % of species described



International Union for Conservation of Nature: www.iucn.org (2007)

Number threatened as the % of species described





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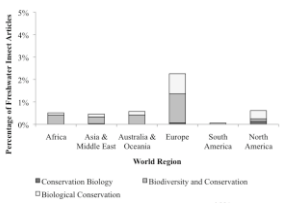
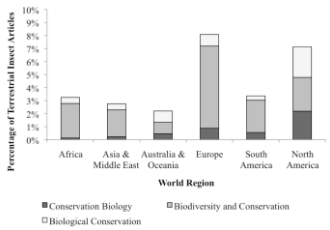




Contador, Kennedy and Rozzi et.al 2009 (in preparation)

Diversity of invertebrates in Chile
(Simonetti et al. 1995)

Tabla 4: Número de especies de invertebrados identificados en Chile

Organismo	Nº de especies	Organismo	Nº de especies
Insectos	12.000	Esponjas	227
Moluscos	1.187	Parásitos	222
Anelidos	700	Collembolas	121
Arácnidos	617	Sipunate, Echura	18
Crustáceos	606	Braquiopodos	18
Bryozoas	470	Hemicordatos	13
Medusas	317		

Fuente: Simonetti et al., 1995. Diversidad Biológica de Chile. *Comisión Nacional de Investigación Científica y Tecnológica. Comisión Nacional de Diversidad Biológica. Chile. Pgs90-280.*
Elaboración: Fundación Terram.
Nota: No se incluyó el número de especies de Phorontda y Chaetognata.

12,000 insect species

Definition of "aquatic insect“:

- Insects that spend at least part of their lives associated with aquatic environments
- Almost all leave water for part of their lives, usually as adults for reproduction
- Aquatic stages are usually immature life stages.

Freshwater insects breath oxygen dissolved in water or from the atmosphere

- 3 major ways aquatic insects obtain oxygen
  - Aeropneusitic
    - Body modifications or behaviors contact insect to atmosphere
    - Bubbles
  - Hydropneustic extract gases directly from water
    - Gills
    - Plastrons

http://www.arbovirus.health.nsw.gov.au/mosquit/photos/aedes_vigilax_larvae.jpg

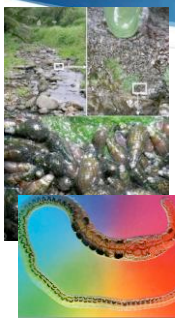
Insects are often the most abundant animal in freshwater streams

There are only 5 insect orders that are exclusively aquatic (Ephemeroptera, Odonata, Plecoptera, Megaloptera, & Trichoptera)

And less than 3% of all species of insects have aquatic life stages, However,

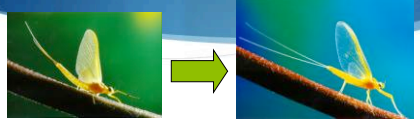
insects often constitute over 90% of the macroinvertebrates (animals that are large enough to see by the unaided eye) in streams.

Benthic macroinvertebrates more than just insects



- Also includes other invertebrates
  - annelids (leeches),
  - oligochaetes (worms),
  - mollusks (clams and mussels), and gastropods (snails).
  - crustaceans (amphipods, crayfish and shrimp),

Life Cycle of Mayfly also hemimetabolous but …



Subimago

Imago (adult)

Nymph or Larvae

egg

Orders common orders

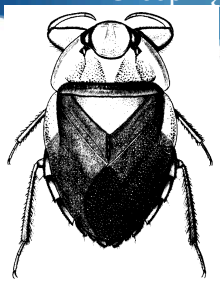
Ephemeroptera (mayflies)

Eggs – larva – subimago - adult
Larvae – elongate, 3 filaments (tail), can have 2.
Lamellate gills along abdomen
Well developed legs, single tarsal claw
Perpendicular wings on adults

Plecoptera (stoneflies)

- Same life cycle as mayflies
- Most have filaments
- No lamellate gills along abdomen
- Some have filamentous gills
- Two tarsal claws
- Adult wings are flat
- Mostly shredders and grazers

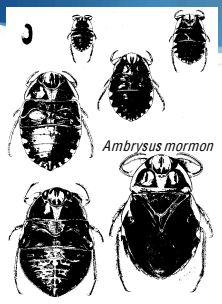
Naucoridae
Creeping water bugs



Modified from McCafferty 1981

- Usually in dense cover of tangled vegetation ponds, lakes
  - some common on gravel and pebble streams
- Predators enlarged femora
- Respiration - air under wings
- do not fly to light
  - attracted to light in water

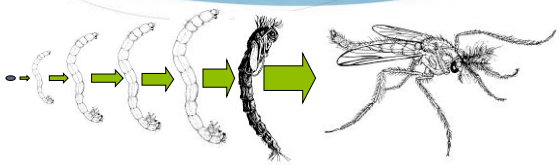
Naucoridae … life cycle



Modified from Usinger 1956

- Typical hemipteran life cycle
  - **Overwinter as adults**
  - **Eggs laid in spring**
    - **glued to stones in shallow water**
    - **hatch ~7 days**
  - **1 week spent in each of the 1st four instars**
  - **5th final instar 3 weeks**

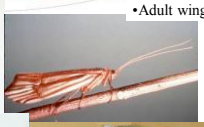
Complete Life Cycle Holometabolous



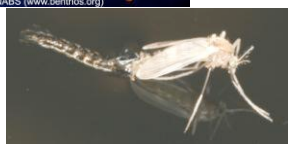
egg → larvae → pupae → adult

Trichoptera (caddisflies)

- Have anal prolegs with hook
- Less visible antennae
- Only order that makes cases
- Adult wings down- very hairy



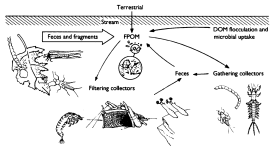
Diptera (midges, mosquitoes, gnats, flies)



- Elongate body
- Segmented body
- Must species rich order (includes Chironomidae)
- Adults have one pair of wings
- Very diverse morphology

Aquatic Insects Function in Aquatic systems

- Trophic relationships constitute the "cement" holding biological communities together
- Cycling and flow of energy involves processing a variety of forms of organic matter by invertebrates particularly aquatic insects



Adapted from Merrit and Cummins

Aquatic ecologists use functional feeding groups to describe feeding in aquatic invertebrates

Cummins 1973 proposed a classification based on how aquatic invertebrates acquire their food based on functional feeding groups

Predators

Shredders

Scrapers

Collector gatherers

Predators --Engulfers

Dragonfly nymph feeding on the earthworm

Predators – Piercers

cells and tissue fluids

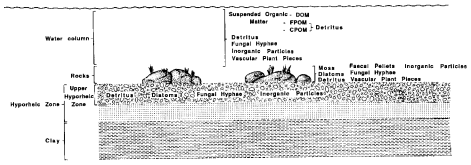
Water Scorpion

Backswimmer

Potential Food in Streams

Allochthonous sources

Autochthonous sources

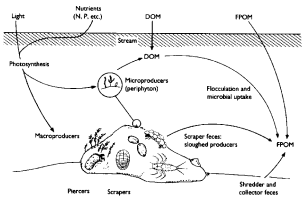


Shredder … Autochthonous sources Allochthonous sources

- Allochthonous source vascular plant tissue from outside the stream channel … Course Particulate Organic Matter (CPOM)
  - Shredders reduce CPOM to FPOM (Fine Particulate Organic Matter) and fecal pellets
  - Energy from fungi & bacteria
  - Life cycle often coincides with autumn leaf fall
- Autochthonous instream sources
  - Macrophytes … aquatic plants

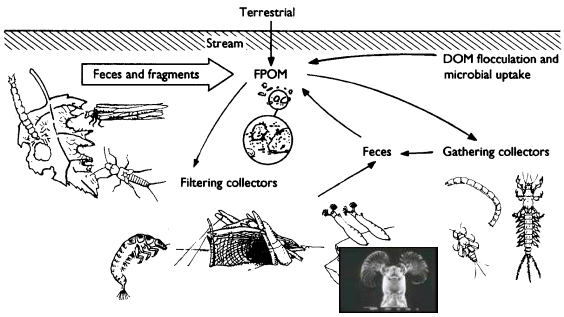
Scrapers (Herbivores)

- Attached algae & microflora on:
  - Mineral surfaces
  - Organic surfaces



Collector Gatherers

Feed on organic particles on substrate or suspended in water

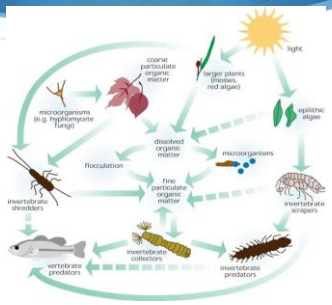


Filter-feeding using a net

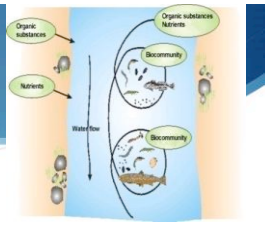
- Nets constructed from silk
- Coarse meshes often spun by species that live in fast currents
- Fine mesh in quieter waters
- Some nets are sticky

Polycentropidae : Neureclipsis

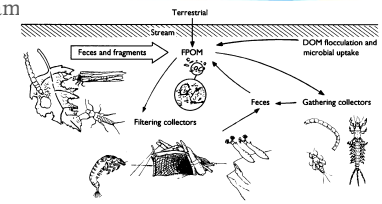
Stream communities are composed of strongly a interacting network of species & functional feeding groups



Nutrient Spiraling

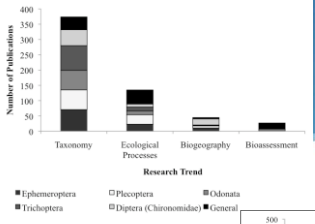


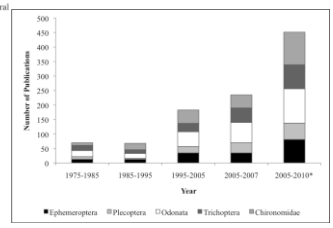
- The reprocessing of organic matter as moves downstream
  - ingestion
  - egestion
  - ingestion
  - entrainment
  - oxidation



State of the taxonomy

- The ability to identify an invertebrate is a fundamental requirement for ecological studies.
- In contrast to the northern hemisphere, taxonomic and ecological studies of aquatic insects in South America have not been as widely researched.
- The bibliography Biota acuatica de Sudameric austral . Edited by S.H. Hurlbert, with sections written by recognized N.A and S.A. taxonomic published in 1970's.
- We've recently completed an exhaustive review of the taxonomic and ecological literature for austral South American Invertebrates. End Notes





Contador, Kennedy and Rozzi et.al 2009 (in preparation)

The extreme southern tip of Chile has an interesting aquatic invertebrate fauna because it has served as a refuge for interesting and ancient evolutionary lineages.

In a study of aquatic macroinvertebrates in D'Agostini National Park

Moorman et al 2006

- Two phyla Annelida and Arthropoda
- Ten orders of aquatic macroinvertebrates
  - Representing twenty-eight species or morpho-species were identified
  - Majority were Arthropoda
  - 79% of invertebrates collected were aquatic insects
  - Some insects known to be very speciose were not identifed beyond family …
    - For example the midges (Diptera: Chironomidae)

Endemic Species

- Temperate forests of southern South America
  - Two species of Stoneflies (Plecoptera)
  - Three species of Mayflies (Ephemeroptera)
  - One Blackfly species (Simulidae: Diptera)
- Several taxa were found that were endemic to the Magallanes and Tierra del Fuego areas,
  - Two Caddisfly (Trichoptera) species
  - One Stonefly (Plecoptera) species

Literature

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