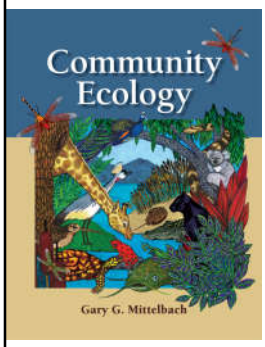
Population and Community Ecology (BSC 441, 541)

- Syllabus
- Course webpage: http://ichthyology.usm.edu/courses/community/
- Course Logistics
  - Labs and field work
  - Exams and papers
  - Groups and projects

New Text!



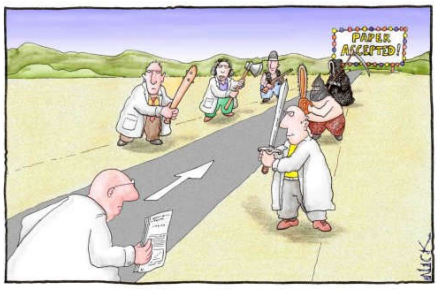
"In Community ecology, Gary Mittelbach takes on the daunting mission of introducing this field. … textbooks reflect, by their omissions, what the authors think is important, and about which they have something important to say. Community ecology, Mittelbach admits, is that kind of book. It reflects his long interest and outstanding contributions to the role of population interactions in regulating diversity and abundance. It is structured like a one-semester course for senior undergrads and graduate students. It will serve that role admirably. … [the] chapters are well organized. … As is befitting a textbook, there is plenty of room for marginalia, the color palette is pleasing, and the figures are beautifully drawn. … As a pedagogical resource for a harried assistant professor, you could not ask for much better … Community ecology is a solid and effective introduction to most of the major questions of the field, written with empathy and clarity by an exceptional community ecologist."
—Michael Kaspari, Ecology

Course Organization

- **Part 1**
  - Review basic ecological principles (niche theory, evolution etc.)
  - Patterns in biodiversity
  - Biodiversity and ecosystem function
- **Part 2**
  - Population growth and dynamics
  - Competition and predation
  - Predation and mutualism
- **Part 3**
  - Ecological networks and food webs
  - Spatial ecology, metapopulations, patch dynamics
  - Neutral theory
- **Part 4**
  - Evolutionary ecology
  - Synthesis and future directions

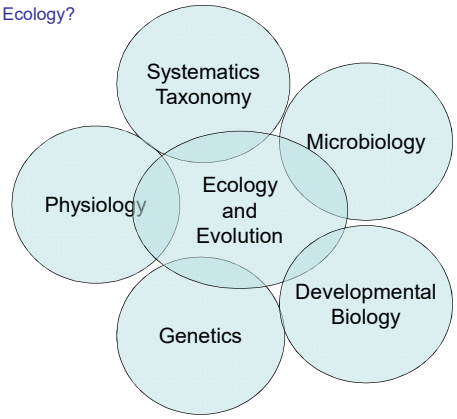
Why the peer review system?

- Science is universally based on the peer review system
- Reviewers = anonymous, independent, and of equal standing (scientist)
- Avoids cronyism, encourages critical and constructive review.



Most scientists regarded the new streamlined peer-review process as 'quite an improvement.'

What is Ecology?



Definitions

- **Ecology** - study of the interactions between organisms and the environment.
  - **Population** - group of interbreeding individuals of the same species. Typically isolated from other groups of the same species.
  - **Community** - assemblage of spatially delimited species. Often defined by a characteristic physical attribute; e.g., the oak- savanna community, or the riffle community in streams.
  - **Ecosystem** – Combination of a community and its physical characteristics. Also includes the ways these organisms interact with the physical space and each other.

Top 25 questions in science…

- What Is the Universe Made Of?
- What is the Biological Basis of Consciousness?
- Why Do Humans Have So Few Genes?
- To What Extent Are Genetic Variation and Personal Health Linked?
- Can the Laws of Physics Be Unified?
- How Much Can Human Life Span Be Extended?
- What Controls Organ Regeneration?
- How Can a Skin Cell Become a Nerve Cell?
- How Does a Single Somatic Cell Become a Whole Plant?
- How Does Earth's Interior Work?
- Are We Alone in the Universe?
- How and Where Did Life on Earth Arise?
- What Determines Species Diversity?
- What Genetic Changes Made Us Uniquely Human?
- How Are Memories Stored and Retrieved?
- How Did Cooperative Behavior Evolve?
- How Will Big Pictures Emerge from a Sea of Biological Data?
- How Far Can We Push Chemical Self-Assembly?
- What Are the Limits of Conventional Computing?
- Can We Selectively Shut Off Immune Responses?
- Do Deeper Principles Underlie Quantum Uncertainty and Nonlocality?
- Is an Effective HIV Vaccine Feasible?
- How Hot Will the Greenhouse World Be?
- What Can Replace Cheap Oil -- and When?
- Will Malthus Continue to Be Wrong?

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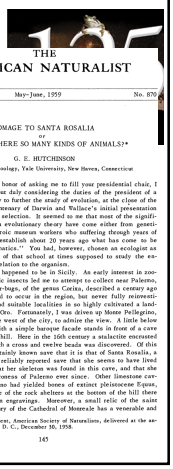

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HOMAGE TO SANTA ROSALIA
or
WHY ARE THERE SO MANY KINDS OF ANIMALS?*

G. E. HUTCHINSON
Department of Zoology, Yale University, New Haven, Connecticut

When you did me the honor of asking me to fill your presidential chair, I accepted perhaps without duly considering the duties of the president of a society, founded largely to further the study of evolution, at the close of the year that marks the centenary of Darwin and Wallace's initial presentation of the theory of natural selection. It seemed to me that most of the significant aspects of modern evolutionary theory have come either from geneticists, or from those heroic museum workers who suffering through years of neglect, were able to establish about 20 years ago what has come to be called the "new systematics." You had, however, chosen an ecologist as your president and one of that school at times supposed to study the environment without any relation to the organism.

A few months later I happened to be in Sicily. An early interest in zoogeography and in aquatic insects led me to attempt to collect near Palermo, certain species of water-bugs, of the genus Corixa, described a century ago by Fieber and supposed to occur in the region, but never fully reinvestigated. It is hard to find suitable localities in so highly cultivated a landscape as the Conca d'Oro. Fortunately, I was driven up Monte Pellegrino, the hill that rises to the west of the city, to admire the view. A little below the summit, a church with a simple baroque facade stands in front of a cave in the limestone of the hill. Here in the 16th century a stalactite encrusted skeleton associated with a cross and twelve beads was discovered. Of this skeleton nothing is certainly known save that it is that of Santa Rosalia, a saint of whom little is reliably reported save that she seems to have lived in the 12th century, that her skeleton was found in this cave, and that she has been the chief patroness of Palermo ever since. Other limestone caverns on Monte Pellegrino had yielded bones of extinct pleistocene Equus, and on the walls of one of the rock shelters at the bottom of the hill there are beautiful Gravettian engravings. Moreover, a small relic of the saint that I saw in the treasury of the Cathedral of Monreale has a venerable and

*Address of the President, American Society of Naturalists, delivered at the annual meeting, Washington, D. C., December 30, 1958.

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Why are there so many species of herbivorous insects in tropical rainforests?

Santa Rosalia revisited: why are there so many species of bacteria?

Why are there so many species?

Why are there so many species of flowering plants?

Why are there so many species in deep-sea sediments?

Why are there so many species in the tropics?

Floodplain biodiversity: why are there so many species?

Darwin's second "abominable mystery": Why are there so many angiosperm species?

Why are there so many species? Scales-temporal heterogeneity and northern bumblebee communities

Abstract

High species diversity in samples of macrobenthos of deep-sea sediments is now well established. But a consensus on the processes regulating this unexpectedly species-rich coexistence in metazoan species at the deep-sea bed is still elusive. This review takes a broad approach by examining differences between marine and terrestrial biodiversity in the context of the following: scale of sampling effort on which our knowledge is based; the species concept as applied in the past to taxonomic studies on deep-sea benthic organisms; scaling differences and size related patterns in community structure and habitat complexity and differences in potential for co-evolution. Latitudinal and bathymetric patterns are summarised in relation to habitat variability and distributional range and in relation to J.S. Gray's (1994) claim that benthic diversity may be equally high on the continental shelf.

Evidence is first reviewed for neo-Darwinian competitive co-existence based on niche specialisation and habitat partitioning. Although evidence for any dietary specialisation is sparse, biologically generated heterogeneity in the sediment, such as from mounds, burrows, tubes and 'mud balls', will persist longer and contribute more to niche diversification than in shallow water owing to slower obliteration by sedimentation and water turbulence.

...disturbance...manipulative experiments...recruitment...succession...patches...invasion

Ecological Sciences Focus on:

- **Organismal** – How individuals are affected by their biotic and abiotic environments
- **Population** – Trends and fluctuations in abundance or density related to biotic or abiotic environment.
  - understand individual responses and apply this understanding to population characteristics (reductionist approach)
  - analyze population characteristics directly and relate these to the environment
- **Community** – How do interactions among species determine distribution and abundance of populations in a particular area or habitat.
- **Ecosystem** – Patterns of energy, mass and nutrientflow through ecosystems.

Ecological Phenomena

- **Pattern** – What we see. Ecologists attempt to fit ecological data to patterns. However, a pattern itself is not meaningful.
- **Process** – What we want to understand. Ecologists ultimately want to understand processes as mechanistic explanations for patterns.
- One goal of ecological science is to predict what will happen to a population, or community under a set of specific circumstances. While founded in basic science, there are clear management implications.

Course Objectives

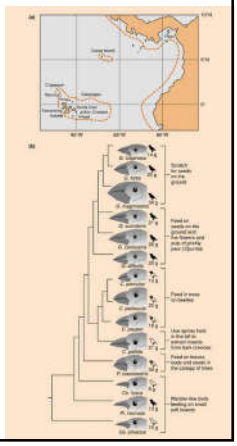
- Understanding of the mechanisms regulating the abundance, distribution and demographics of populations
- Understanding of the mechanisms regulating the dynamics, composition and organization of groups of species (communities)
- Introduction to some of the tools necessary for the design of population/community ecology experiments. These tools include sampling procedures, data collection, data analysis and hypothesis testing.

Modern Synthesis of Evolution (Theodosius Dobzhansky)

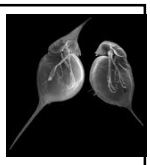
- Population biology:
  - 1. Populations will grow exponentially if unchecked
  - 2. Populations do not grow exponentially
  - 3. Populations limited by one or more limiting resources
- Genetics:
  - 4. Populations are variable
  - 5. Variability is heritable
  - 6. Ability to acquire resources (including limiting resources) related to heritable traits
- Natural Selection:
  - 7. Variability in resource acquisition results in unequal survivorship and reproduction
  - 8. Unequal survivorship and reproduction result in changes in gene frequency over time

"Nothing in Biology Makes Sense Except in the Light of Evolution" T. Dobzhansky

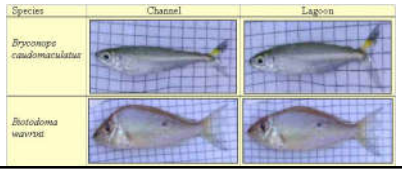
- **Natural Selection**
  - Heritable variability → differential reproductive success
- **Fitness**
  - Genetic contribution an individual makes to the next generation relative to others in the population
  - Not survivorship
  - Not fecundity
- **Species**
  - Morphological
  - Biological
  - Phylogenetic
  - Ecological
- Why is a "species" difficult to define?



Polymorphisms and Plasticity

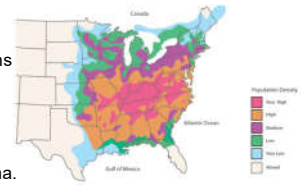


- Within a population, variability is maintained through:
- **Polymorphisms** – multiple alleles maintained in a population
  - Selection forces change over a gradient
  - Heterozygote advantage
  - Selection against most common alleles (eg. color morphs)
  - Habitat mosaic results in different selection forces
- **Plasticity** – one genotype capable of producing multiple phenotypes
  - response to environmental cues.



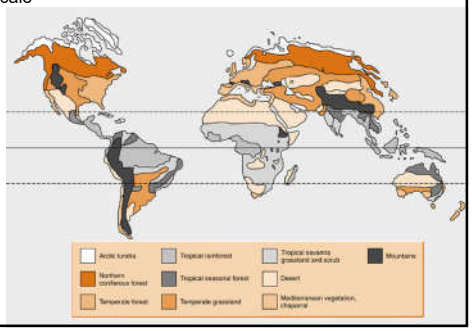
Natural Selection

- Selection should act to maximize fitness for a population in the environment where it occurs.
- Species (or populations) are expected to have optimal conditions in which fitness is maximized.
- Thus, for any given species there will be a set of environmental conditions that represent the optima.
- We expect this optima to coincide with the species distribution and local abundance.
- Environments are complicated…



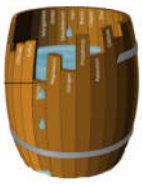
Environments

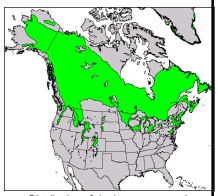
- Patchy, variable, often stochastic
- Numerous overlapping gradients
- Presence of a species may change a habitat
- Designated "biomes" are artificial
- Importance of scale



Liebig's Law

- Idea developed in agriculture – single limiting factor usually determines crop yield.
- Ecologically, distributions (presence at one location) may be determined locally by a single limiting factor (temperature, pH, moisture, salinity, etc.)





Distribution of *Juniperus communis*

Fitness and ecological gradients

- Species are distributed across multiple gradients, demonstrate maximum fitness near optima.
- For a population, population size is theoretically maximized at this optima