به نام یگانه آفریننده دانا

دانشگاه حکیم سبزواری

بیوسیستماتیک جانوری

تهیه کننده

علیرضا کیخسروی

نیمسال اول ۱۳۹۵

References

- Mayr, E. and Ashlock, P. D. 1991. Principles of systematic zoology
- Kapoor, P. C. 1992. Theory and practice of animal taxonomy,
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- Simpson , G. 1990. Principle of animal taxonomy.

سرفصل مطالب

- جایگاه بیوسیستماتیک، تاکسونومی و رده بندی در علوم محض و کاربردی
- تاکسونومی و تنوع زیستی در گذشته، حال و آینده
- میکروتاکسونومی (فنون، تاکسون، رسته و رده بندی گونه)
- نگرش اجمالی بر مفاهیم گونه ای نامی، ریختی، تکاملی و زیستی)
- تاکسون گونه، زیر گونه و سطوح فراگونه ای
- تاکسونومی جمعیتی و تنوعات درون جمعیتی
- گونه زایی و تعیین حدود گونه ها
- دیدگاه ها در مکتب تکاملی
- دیدگاه ها در مکتب فنتیکی
- دیدگاه ها در مکتب کلادیستیک
- صفات تاکسونومیک
- موزه و موزه داری
- انتشارات تاکسونومیک
- قواعد نامگذاری جانوری

Taxonomy

- *Taxis* (ordering) + *nomos* (law)
- Taxonomy is defined as:

The theoretical and practical science for animal classification.

Systematic

Systematic *Systema*

Although the words taxonomy and systematic are sometimes used interchangeably, the definition followed in this book (chapter 1) considers taxonomy to be the part of systematic dealing with the description, naming, and classification of organisms. Systematic, by this definition, is the entire scientific field that "deals with the organization, history, and evolution of life. It ultimately asks, how did life forms originate? How did they diversify and how are they distributed both in space and time?"

(Novacek, 1992:103)

- **Alpha Taxonomy:**

Recognizing new species and describing them

- **Beta Taxonomy:**

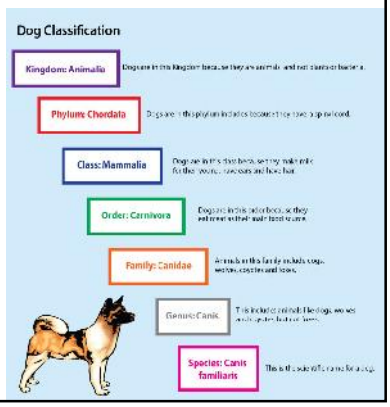
Grouping them in a natural system of hierarchy

- **Gama Taxonomy:**

Analyzing the intraspecific variation and studying on evolutionary and taxonomic relationship

Systematic and biology

- Taxonomy was pioneer in all branches in biology (i.e. Genetic, Ecology, Evolution and etc.)
- A need for a correct classification.



Systematic as an applied field

- Examples:
- *Anopheles maculipennis*

It was thought first that this mosquito is only one species but later behavioral studies showed they are more.

- *Syagrius fulvitarsis* (parasite)

Baraconidae (prasitoid)

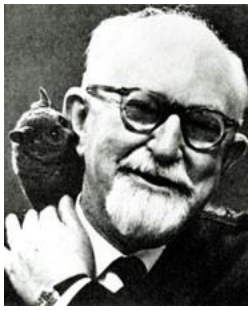
Therefore how taxonomy play role?

- It is not only for curator at museums
- Economy
- Evolutionary history
- Ecology
- Behaviour
- Biogeography

This science is not only for description of life

History of taxonomy

- Simpson, 1961
- Mayr, 1982
- Hippocrates 400 BC
- Aristotle (the father of classification science)
- Linnaeus



Downward classification

- This method was used by Cesalpino (1509-1603) and Linnaeus (1707-1778)
  - Dichotomy
- Disadvantageous
  - Only for identification
  - Not able to make an order in widespread fauna

Upward classification

- Mid-eighteenth centuries
  - Grouping based on similarities (Bufon)
- Other development s in taxonomy (between linnaeus and Darwin)
  - Studies become specific
  - Hierarchical classification
  - It became an empirical enterprise
  - A search for finding a natural system was intensified
- Effect of the origin of species book on taxonomy
  - Common ancestor

- Microtaxonomy
  - Introduction
  - Species category
  - Species taxon
  - Intraspecific variation
  - Speciation and taxonomic decision

Population systematic

- Conflict between essentialist and population thinking
  - Start from early nintheen century up to 1930 -1940
  - Named modern systematic in 1940 by Huxley
  - Population systematic is not a substitute for classical taxonomy is not only morph but also includes physiology, biochemistry and ….

Microtaxonomy

- **What is microtaxonomy?**

  - Species problems:

  - Confusion in concept involving the basic terms (i.e. phenon, Taxon and Category)

  - Discontiniuty between the terms: individual and reproductively isolated population

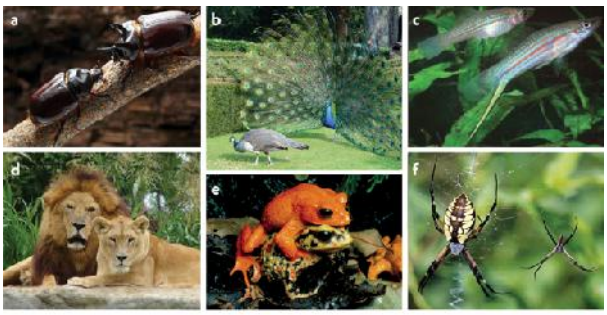
  - Incipient species

Phenon

- Camp and Gilly (1943) to describe homogeneous samples at species level but later was developed by Sokal and Sneath 1973.

Varieties at population level:

- Sex dimorphism.



Nature Reviews | Genetics

Phenon

- Camp and Gilly (1943) to describe homogeneous samples at species level.

Varieties at population level:

- Sex dimorphism.

Mallard (*Anas platyrhynchos*)

Phenon

Varieties at population level:

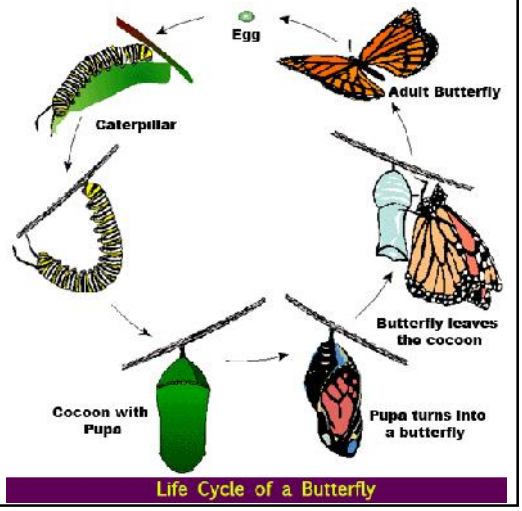
- Sex dimorphism.
- Age

Seagull or gull

Phenon

Varieties at population level:

- Sex dimorphism.
- Age
- Stage



Phenon

Varieties at population level:

- Sex dimorphism.
- Age
- Stage
- Seasonal varieties.

Arctic fox

Phenon

Varieties at population level:

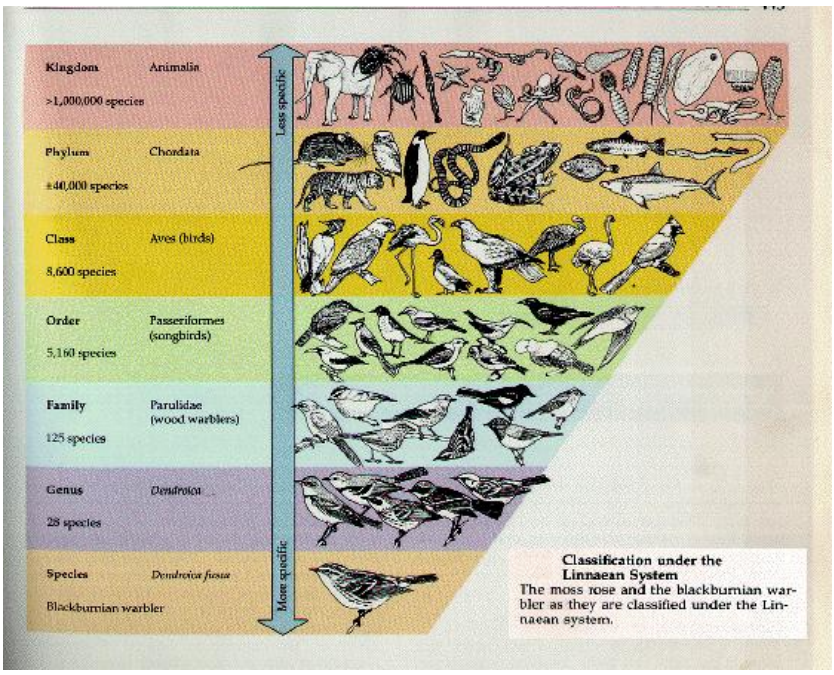
- Sex dimorphism.
- Age
- Stage
- Seasonal varieties.
- Morphs (individual variability).

Reed frog

Taxon

- Simpson 1961 (definition)
- Two aspects must be stressed, taxon:
  - Refer to concrete zoological object, therefore species is not a taxon
  - Taxon must be officially recognized by taxonomists

  Examples: blue birds, **Larks**
- Historical groups (wiley, 1981).
  - Higher taxa lack degree of cohesion as species does.

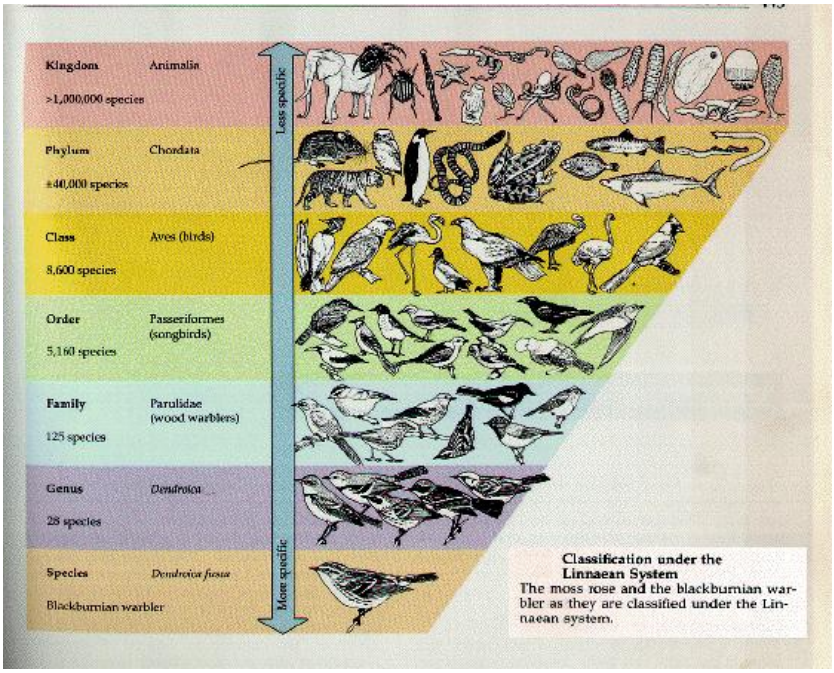


Taxon

- How Phena and Sibling species make problem in classification.

Category

- Means rank or level in hierarchic classification.
- They naturally fall into three groups:
  - The species category
  - Subspecies for distinguishing population within species.
  - Above the species level.

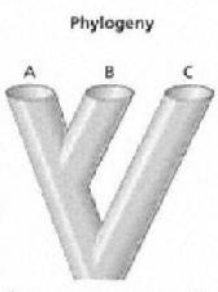


Tell me now what is the relationship between species and classification?

- Every phyletic line and every higher taxa originated through a speciation event, but only microtaxonomy is important at species level not speciation??
- This is supported by new taxonomy (1930).
  - Geographical variation
  - Polytypic species
  - Incipient species and etc.
- Macrotaxonomy (1960) and its connection to microtaxonomy,

  Species are the vehicle of all macroevolution

  or Species are the real unit of evolution



Microtaxonomy

The Species Category

The Species Taxon

The Species Category

How to define Species delimitation

- Species Concept
  - Typological
  - Nominalistic
  - Biological
  - Evolutionary

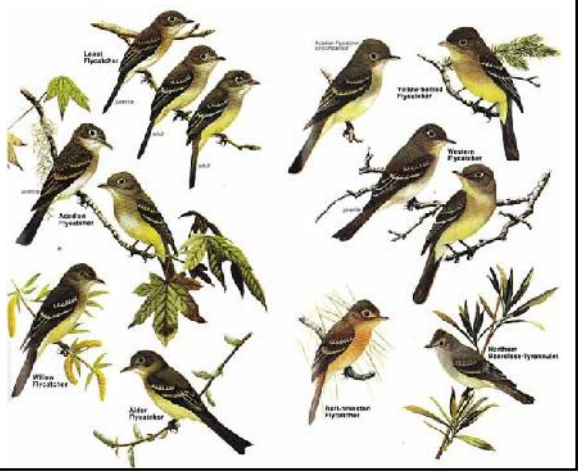
Typological or Essentialism Species Concept

(Linnaeus and his followers)

- Observed diversity = existence of limited number of types.
- No any special relationship
- Using morphological evidence
- In their concept species consist of:
  - Similar individual sharing the same essence
  - Separated by distinct discontinuity
  - Constant through time
  - Limited variation within any species

Shortcomings of the definition

- Conflicting with Phena
- Sibling species or Cryptic species



Nominalistic Species Concept

(Occam and his followers)

- Denying the existence the “real” universal
- Species is created by human thought

Easy to reject it

Biological Species Concept

(Late eighteenth century, Buffon and ….)

- Jordan was the first who formulated the concept
- It differs from the last two definition by
  - Stressing the population nature
  - Genetic cohesion
  - Pointing out species‘ reality comes from the historically evolved shared information in its gene pool

Characteristics

- Reproductive society
- Ecological unit
- Genetic unit

By this, biological species is not the same as other species

Shortcomings of the definition

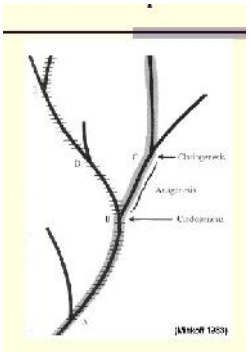
- It is relational term (A is species in relation to B)
  - Space
  - Time

Species Recognition Concept (Peterson, 1985)

Evolutionary Species Concept

- Simpson (1961) definition (An evolutionary criteria)

"It is a lineage evolving separately from the others "



Difficulties

- This is a definition of phyletic lineage

It solve the time dimension but it denies the real problem of the species; the causation and maintenance of discontinuity of between contemporary species

- Modern evolutionary synthesis
- Reviewing the cited litrature in page 48
- A species definition for the Modern Synthesis

From phenon to taxon and category

- Paleontologist problem
- Taxonomist in fact use evidence to make a decision what taxon they do belong.
- Reproductive isolation not only protect gene pool but also morphology and other aspects of phenotype produced by genotype (for preserved sample and fossil record).
- Biological taxonomist and typological taxonomist use morphlological characters differently.
- Importance of molecular data

Difficulties in application of biological definition

1- Insufficient information

2- Uniparental reproduction

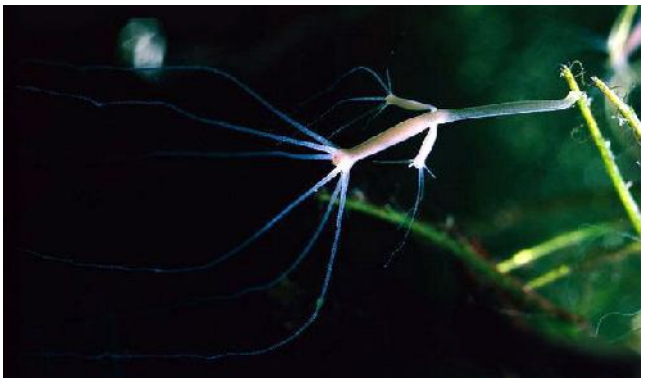
- Automixis "away from" + "mixing" : asexual reproduction, without fertilization. This definition notably does not mention meiosis.

Partenogenesis

- In animals, parthenogenesis means development of an embryo from an unfertilized egg cell.

The asexual, all-female whiptail species *Cnemidophorus neomexicanus* (center), which reproduces via parthenogenesis, is shown flanked by two sexual species having males *C. inornatus* (left) and *C. tigris* (right), which hybridized naturally to form the *C. neomexicanus* species.

Vegetative reproduction



Self fertilizing hermaphroditism

- Hermaphroditism occurs when a given individual in a species possesses both male and female reproductive organs, or can alternate between possessing first one, and then the other.

An anemone fish couple guarding their anemone. If the female dies, a juvenile male moves in, and the resident male changes sex.

Gynogenesis

- form of asexual reproduction related to parthenogenesis is gynogenesis. Here, offspring are produced by the same mechanism as in arthenogenesis, but with the requirement that the egg merely be stimulated by the *presence* of sperm in order to develop

Spotted salamander, *Ambystoma maculatum*

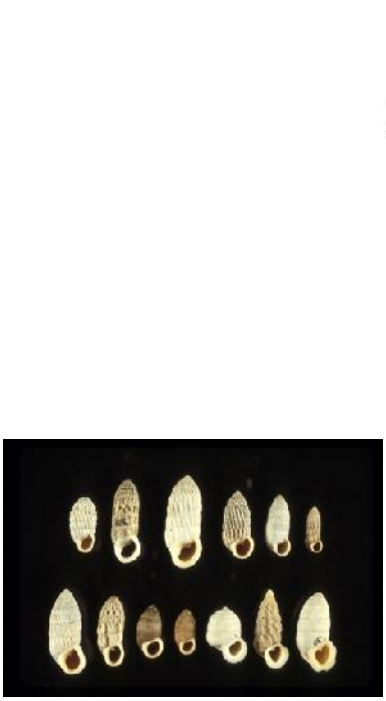
Uniparental

- Sometimes called, agamospecies, binomes, paraspecies
- Daphnia, rotifer, aphids have alternation between sexual and parthenogenetic generation. therefore they are temporary clone and based on nomenclature can be not called

3- Evolutionary intermediacy

1- Acquisition of reproductive isolation without equivalent morphological change

2- Acquisition of morphological difference without reproductive isolation



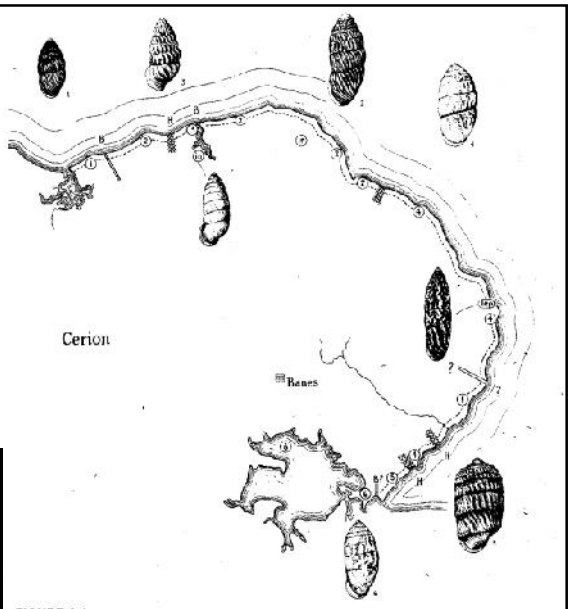


FIGURE 2-1
Irregular distribution of populations of the halophilous land snail *Cerion* in eastern Cuba. Numbers refer to different races or species. Where two populations come in contact (with the exception of *hyalcida*), they hybridize (H) regardless of difference. In other cases contact is prevented by a barrier (B). in = isolated populations. (*From Mayr 1963.*)

3- occasional breakdown of isolating mechanism

The hybrid between a jack and a mare is a mule

a - Hybrid swarms
b - Parthenogetic species formed through hybridization

Thelytoky (from the Greek *thēlys* "female" and *tokos* "birth") is a type of parthenogenesis in which females are produced from unfertilized eggs.

4- semi species and allospecies

- Superspecies
- Subspecies

Meaning of the species categotry

- Monotypic taxons
- Local phena
- The proper assignment of allopatric and allochronic populations

The species taxon

- Species definition:
  - by old philosophers
  - By naturalist

Need for help to assemble the book

The species taxon

- Polytypic species
- Importance of the detecting polytypic species
  - Easiness
  - Restoration of biological meaning and homogeneity to the species category

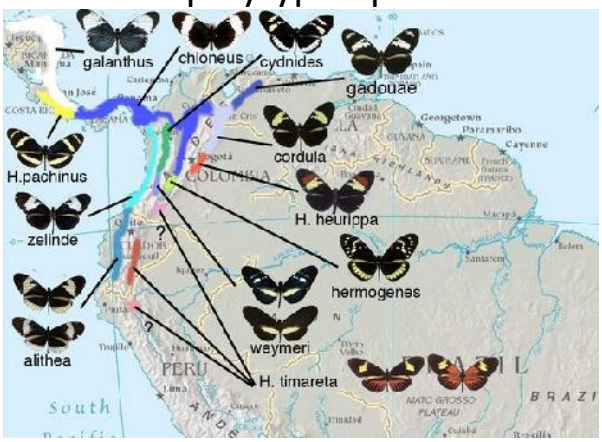
The best evidence for allopatric speciation and evolutionary innovation

difficulties

- Lack of criteria for subspecies definition
- Species with the same ecological requirements
- Isolated population are on the border line between species and subspecies

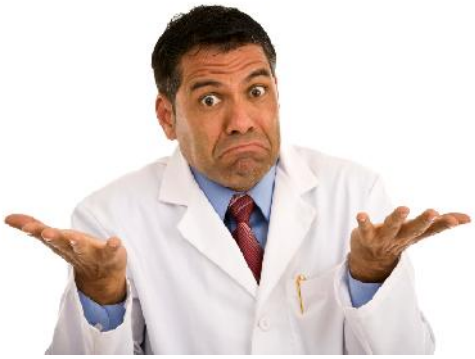
Polytypic species in animal kingdom

- What group has more polytypic species
- Dimensions in polytypic species



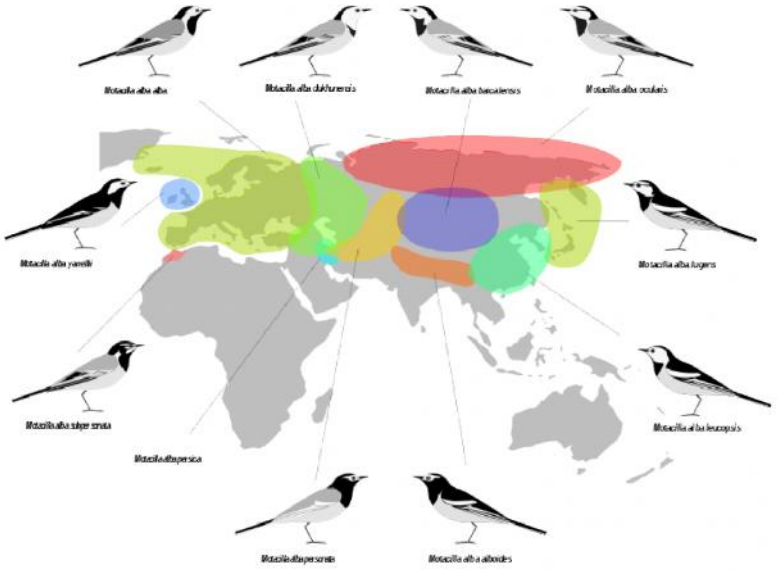
Nomenclature problems

- There were first monotypic but now……
- Who is the real author?



Mutacilla alba

Conservation status	
Extinct / Threatened / Least Concern	EX EW CR EN VU NT LC
Least Concern (IUCN 3.1)[1]	
Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Order:	Passeriformes
Family:	Motacillidae
Genus:	*Motacilla*
Species:	***M. alba***
Binomial name	
Motacilla alba	
Linnaeus, 1758	



Intraspecific categories and terms

1- Variety

Intraspecific categories and terms

1- Variety

- The subspecies (overlapping)
  - Nineteen century
  - Wrong application
  - Subspecies are allopatric and allochronic
    - Exception migratory birds and parasites
  - definition

The subspecies may be defined as follows: *A subspecies is an aggregate of phenotypically similar populations of a species inhabiting a geographic subdivision of the range of that species and differing taxonomically from other populations of that species.*

Difficulties in the application of species category

- Independent trend of geographic variation for different character
- The independent occurrence of similar or phenotypically indistinguishable populations in geographically separated areas
- Occurrence of microgeographic races within formally recognized subspecies
- Arbitrary the degree of distinction considered by different specialist

Intraspecific categories and terms

1- Variety

- The subspecies (overlapping)
- Temporal species

Intraspecific categories and terms

1- Variety

- The subspecies (overlapping)
- Temporal species
- Races

Intraspecific categories and terms

1- Variety

- The subspecies (overlapping)
- Temporal species
- Races
- Cline
  - Huxley 1939
  - Isophen
  - Two opposite end population can be two subspecies

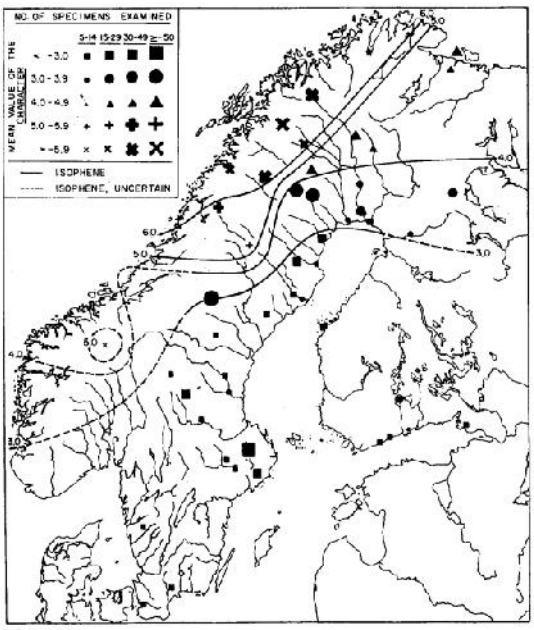


FIGURE 3-1
Cline in the darkness of the upper side at different Fennoscandian localities of *Pieris napi* females of the first generation. Isophenes of various darkness values are indicated on the map. (*From Petersen 1949.*)

Population taxonomy

- When the term “population” came along the typological definition was replaced by Biological definition

Why

Because:

It is not only morph that has to be considered

And vast sampling is needed not only couple of specimens and the rest are just repetition

Infrasubspecific categories

- Natio
- Some terms are neutral in population
  - Forms
  - Species complex instead of subgenus example *drosophila* and *Garrulus glandarius* (28 subspecies)

  - Series, section and division

Population taxonomy

- Another important task for taxonomist

Population features

- continuity
- Geographic isolate
  - Incipient species
  - Evolutionary unit
- Secondary contact zone

biosystematic

- Accept population
- Different methods other that purely morph
- Individual and geographical variation using statistical methods

Superspecies

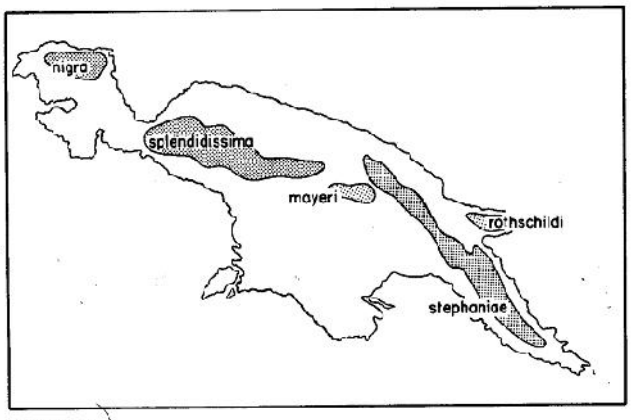


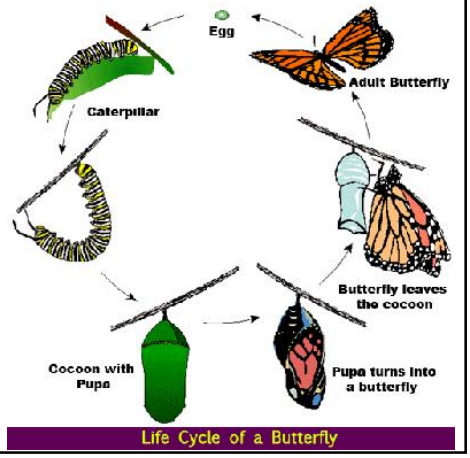
FIGURE 3-4
A superspecies of paradise magpies (*Astrapia*) in the mountains of New Guinea. Some hybridization has been recorded in the zone of contact between *mayeri* and *stephaniae*. (*From Mayr 1963.*)

intra-population variability and comparison

- Same morph
  - phena of the individual species (no reproductive isolation)
  - Sibling species (reproductive isolation)
- Different morph
  - Different phena of the same species (no reproductive isolation)
  - Different species (reproductive isolation)

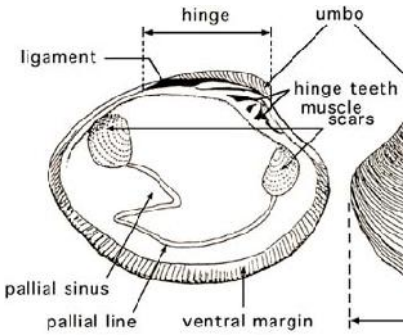
Sympatric specimens

- Problems in diagnosis:
- extreme differences in phena of the same species
- Sibling species
- Morph overlapping



Phena or different species

- Some characters are very stable at intra-specific level
  - Genitalia
  - Hinge
  - Palp



Principle of covariation

- Difference in character also finding difference in unrelated character b, c, d and etc
  - Minvet birds: **short-billed minivet** (*Pericrocotus brevirostris*)

Non genetic variation

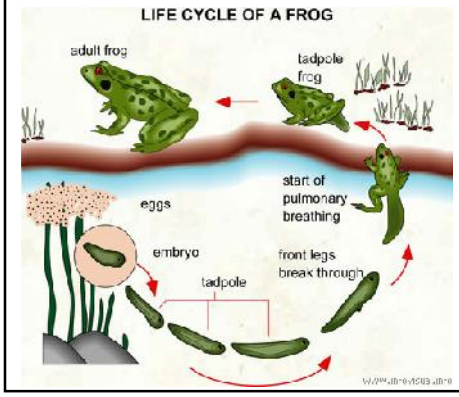
- Ecological variation
- Social variation
- Traumatic variation
- Individual variation in time

Non genetic variation

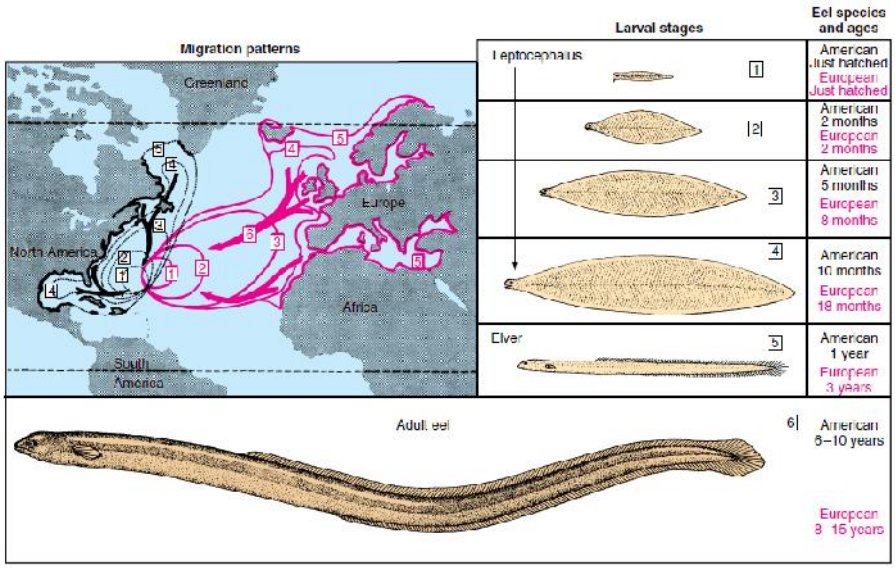
- Individual variation in time
  - Age variation
  - Seasonal variation
  - Seasonal variation in an individual

1- Age variation

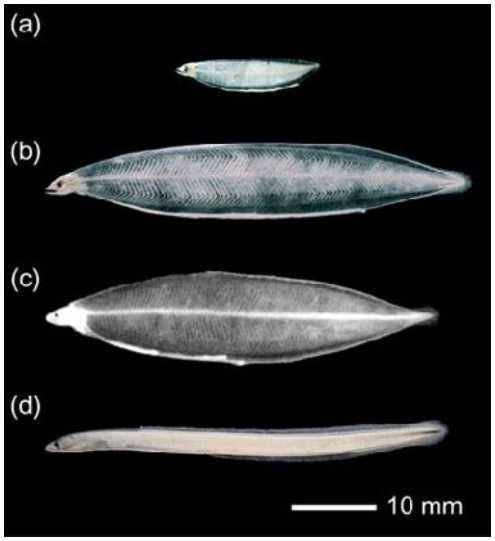
- Too easy
- Too difficult



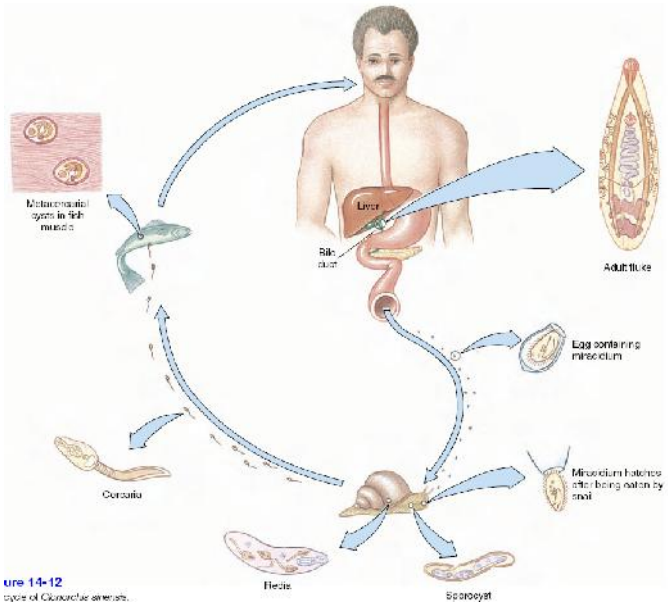
مهاجرت در مارماهی آمریکا و اروپا که catadromus (ساکن اصلی رودخانه ها) هستند



Leptocephalus brevirostris



انگل کبد انسان *Colonorchis sinensis* معروف



2- Seasonal variation in consecutive generation

- seasonal variation in consecutive generations e.g. Insects (dry season and wet season phena) e.g. some freshwater organisms (Cyclomorphosis) rotifers and cladocerans Changes through the season in connection with water properties (temperature, …)

- Cyclomorphosis:
  - rotifera and cladocera

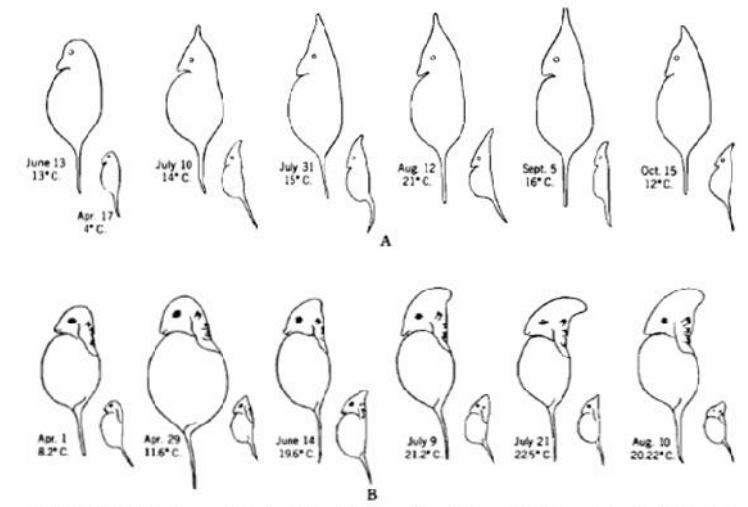
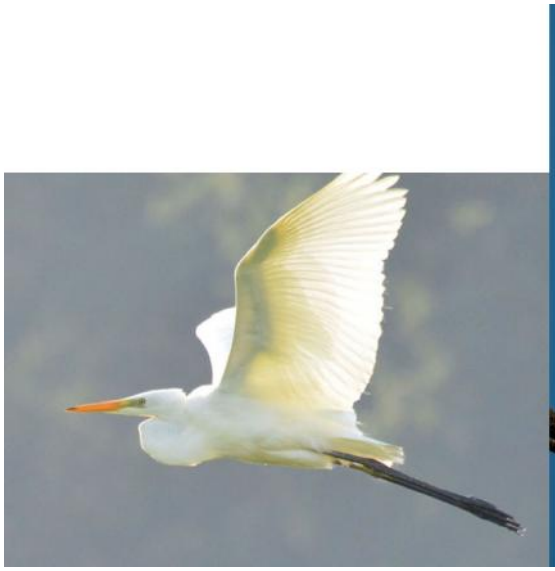


FIGURE 16-38 Cyclomorphosis in (a) *Daphnia cucullata* of Esrom So, Denmark and (b) *Daphnia retrocurva* of Bantam Lake, Connecticut. The small individuals at the right are first instar juveniles drawn to the same scale as the adults. (a) From Hutchinson, G. E.: *A Treatise on Limnology*, Vol. 2, New York, John Wiley & Sons, Inc., 1967; (b) From Brooks, John Langdon: Cyclomorphosis in *Daphnia*: *Ecological Monographs* 16:1946. Copyright 1946 by Duke University Press.)

Non genetic variation

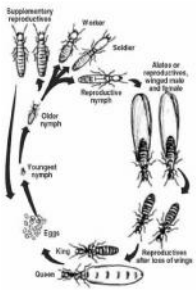
- Individual variation in time
  - Age variation
  - Seasonal variation in consecutive generation
  - Seasonal variation in an individual

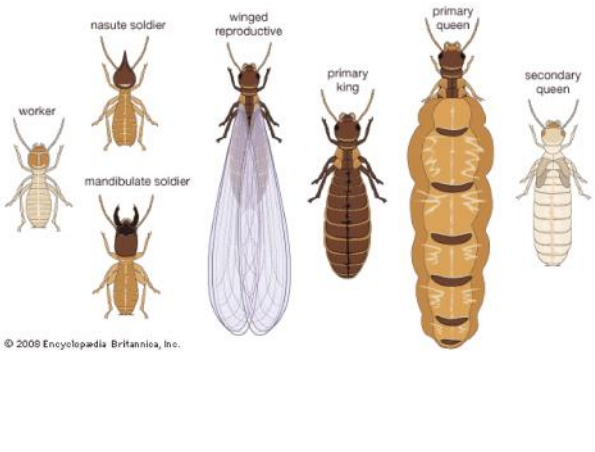
3- Seasonal variation in an individual



Social variation

- **Insect Castes (Hymenoptera, Isoptera)**
- Queen
- Males
- Workers
- Soldiers





Ecological variation

- Habitat changes
  - Microsubspecies or ecological races
  - Non genetic ecophenotype
- Climate change
- Host changes
- Density changes
- Allometric growth
- Neurogenic or hormonal

More than 251 invalid species!!

Ecological variation

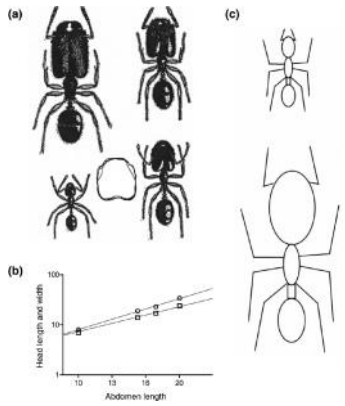
- Habitat changes
- Climate change
  - variation induced by temporary climatic conditions (drought, cold, food supply, etc.) Produce year classes, rapid or slow growth

Ecological variation

- Habitat changes
- Climate change
- Host changes
- Density changes
  - One of the more dramatic examples of phenotypic plasticity is the density-dependent phase change seen in many insects, particularly members of the Orthoptera (e.g. locusts and grasshoppers) and the Lepidoptera (e.g. armyworms). Individuals in both taxa can exist in solitary (low-density) and gregarious (high-density) forms, and it is well documented that these two forms can have significant divergences in physiology, behaviour and ecology (Applebaum and Hei- Fetz 1999).

Ecological variation

- Habitat changes
- Climate change
- Host changes
- Density changes
- Allometric growth
- Neurogenic or hormonal



Traumatic change

- Parasite-induced variation
- Accidental and teratological variation

(post mortem changes)

Parasitic induced variation

- Stylopes and sand bees

Intra-populational variation
Genetic variation

- **1. Sexual dimorphism**

1.1 Primary sex differences

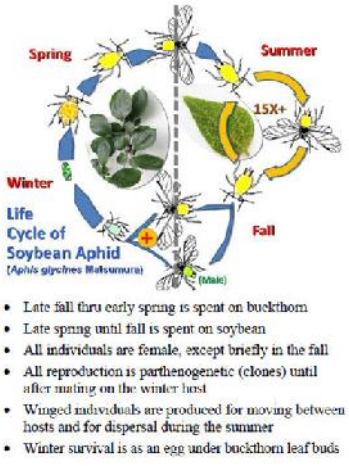
1.2 secondary sex differences

1.3 Gynandromorphs and
intersexes (in interspecific hybrids)

Intra-populational variation
Genetic variation

- **2. reproductively different generations**

alternation of generations



- Late fall thru early spring is spent on buckthorn
- Late spring until fall is spent on soybean
- All individuals are female, except briefly in the fall
- All reproduction is parthenogenetic (clones) until after mating on the winter host
- Winged individuals are produced for moving between hosts and for dispersal during the summer
- Winter survival is as an egg under buckthorn leaf buds

Intra-populational variation
Genetic variation

- **3. Ordinary genetic variation**

3.1 Discontinuous variation (genetic polymorphism)
(e.g. Mimetic polymorphisms)
Papilio dardanus complex: 1 male and 5 female morphs
(3 of them mimics of two other butterfly families)

3.2 Continuous variation
(slight genetic and morphologic differences)
Studying character by character

Comparison of population samples

- Qualitative character
- Quantitative character

Statistical analysis

Measurements and counts

scaling

accuracy

- Gradient in species is the problem
- Combined concept????
- Recognition compatible mate recognition
- Intrinsic coherent mechanism = cohesion concept
- Monophyletic = derived character
- What was the last definition
- How amazing is a teacher
- Morph and genetic is the most important one
- Lineage species concept !!!!!!!!
- Does the bifurcation keep the live fossils
- What means population is the same as species
- What to be used in biological definition evolutionary definition say terminals are different species

Macrotaxonomy

General rules of classification

- Items that are to be classified are assembled in classes that are made as homogeneous as possible.
- An individual item is included in that class with the member of which it shares the greatest number of attributes
- A separate class is established for any item that is too different to be included in one of the previously established classes.
- The degree of difference among the classes is expressed by arranging them in a hierarchy of nested sets. Each categorical level in hierarchy expresses a certain level of distinctness.

Additional rules

- Classification based on some defining quality is not useful and legitimate when actually it is in result of history or another cause.

  e.g., quick and slow recovery for diseases

- As result similarity and sameness of causation are responsible for the grouping

Special classifications

- Sometimes special classification based on single characteristics are needed for instance:
  - Diploid Vs polyploid
  - Annual Vs prenial

identification

- Fundamental difference between classification and identification
  - Classification orders a diversity of items into groups or taxa based on principles
  - Identification is the placement of an undefined specimen in one taxon or group
  - In identification use a few characters and it is based on deductive reasoning
  - classification is a filing system

identification

- Prior to Linnaeus classification was actually identification schemes (downward classification)

Criteria of zoological classification

- Pre-darwinian (Similarity)
- Darwin (Common descend and genealogy)
- Hennig (similarity, Homoplasy, synapomorphy)

Phylogeny and classification

- Neither phylogeny is based on classification nor is classification based on phylogeny
- Both science:
  - Study on natural groups. Groups with character combinations expect in the descendant of the same ancestor
  - Based on the same comparison of organisms and their characteristics and on evaluation of similarities and differences

What is the evidence that permit inferences in phylogeny?

- Taxonomic characters
- Fossils
  - Archaeopteryx
  - Seymouria
  - Fossil records create difficulties if:
    - Aberrant or belong to extinct groups
- Geographic distribution

Three schools of macrotaxonomy

- How classification can reflect both similarity and descent (a source of disagreement)
- Four steps for solving the conflict:
  - Giving primacy to one of the two sets of criteria, hoping that the result will satisfy the other set:
    - Phenetics
    - Cladistics
  - To consider the two sets of criteria equally but sequentially:
    - Evolutionary taxonomy
    - Some school of cladistics