PRINCIPLES OF SYSTEMATIC ZOOLOGY

LECTURE 1

Taxonomy

The term Taxonomy is derived from a Greek word "Taxis" which means arrangement and "Nomos" means laws.

Thus we can define Taxonomy as "The theory and practice of classification of organisms."

Systematics

The term Systematics is from Latinized Greek word 'Systema' which is applied to the earlier classification by the early Naturalists. Notably Linnaeus.

According to Simpson (1961)"Systematics is the scientific study of the kinds and diversity of organisms and of any and all relationship among them.

Or Systematics is the science of diversity of organisms.

Systematics is a broad term which includes Taxonomy, Nomenclature and classification etc.

Taxon

A taxon is a group of real organisms recognized as a formal unit at any level of a hierarchic classification.

Or a taxon is a name of taxonomic group of any rank that is considered by taxonomists to be formally recognized and assigned to a definite category.

The words Blue birds, Song birds, Vertebrates refers to group of organisms .such complete objects of zoological classification are taxon.

Taxon always refers to concrete zoological object, thus the species of a Robin is not a taxon but a category while Robin is a taxon.

The taxon must be recognized by the taxonomists within any large genus. They are taxa if they are early recognized and named.

Category

A category designates rank or level in a hierarchic classification.

OR

A Category is a class whose members are all the taxa assigned a given rank.

- Kingdom Animalia
- Phylum Chordata
- Class Mammalia
- Order Primates
- Family Hominidae
- Genus Homo
- Species *Homo sapiens*

LECTURE 2

Contribution of systematics to Biology

Theoretical biology

Theoretical Biology searches to discover characteristic principles of order within the variety of biological phenomena by describing the organizational dynamics of living systems in a formal way. In addition to a more profound understanding of single phenomena, it has brought about new starting points in the search for answers to the most fundamental questions in biology

Theoretical Biology stays in intimate dialogue with experimental biological research. However, in contrast to the latter it uses mathematics as its language and computers as the most important tools

The precise definition of biological terms and the characterization of cognition by using formal systems, in general, are fundamental tasks of Theoretical Biology now and in future.

Theoretical Biology is naturally interdisciplinary. It draws ideas from other disciplines and, in reverse, supports them by quantification and precision. Therefore, it is on the way to become a general and extensive structural science of organized systems, which might be able to point out similarities between the organization of physio-chemical, biological, economical, and social systems

Population systematics

Ethology

Evolution

Applied biology

Applied Biology is the understanding of how organisms work from subcellular to whole organism level. It also involves the use of living organisms (mostly microbes) to produce useful products. It includes traditional processes like brewing, cheese making and modern developments such as genetic engineering which can lead to new drugs against cancer and other diseases.

Public health

Biological control

Conservation of species

Biological war

LECTURE 3

HISTORY OF TAXONOMY

Mayr described the history of taxonomy in four periods.

1st Period 2nd Period 3rd Period 4th Period

1st Period (Study of local fauna)

Native of primitive tribes were excellent naturalist.

Study of fauna came from the contribution of Greek scholars.

Aristotle(384-322 BC) ,known as the father of biological classification ,referred to major groups of animals as birds, fishes, whales and insects.

Aristotle thinking dominated for next two thousand years.

There are two major form of classification in first period.

1) Downward classification``` 2) Upward classification

Downward classification

Taxonomy based on local fauna reached its peak by the work of Linnaeus (1707-1778).

The method of downward classification are principles of logical division which consists of dividing larger groups by dichotomy into smaller groups. E.g. Animals

Linnaeus adopted the principle of downward classification in 15th edition of his book (Systema naturae)

He for the first time applied Binomial nomenclature to animal kingdom.

Linnaeus believed in fixity of species.

Upward classification

By the mid of 18th century the shortcomings of downward classification were recognized.

Gradually it was replaced by upward classification.

It consists of assembling species by inspection into a group of similar or related species and formin g hierarchy by again grouping of similar taxa of next lower rank.

This thought was applied by a botanist in 1873 and later by nearly all zoologists.

This shift from downward classification to upward classification was a major philosophic change.

<u>2nd Period (Acceptance of evolution)</u>

Evolutionary thought was widespread in 18th century but owes its foundation to second period.

Darwin believed in fixity of species .but after observing natural fauna in Galapagos island, he begin to believe in the plasticity of species.

Empirical taxonomists were greatly influenced by his idea.

The phylogenetic tree of Ernest Haeckel also stimulated the empirical workers.

Large number of new species were discovered and described.

<u>3rd Period (Population systematics)</u>

The greatest development of modern taxonomy started around 1930, when the workers realized that the Linnaeus species based on one or two specimens are not as perfect as those which are based on population.

Due to this Mayr in 1942 considered species as a group of interbreeding natural population.

This idea of population taxonomy was useful in developing the polytypic concept.

New terms like new systematics and biosystematics were added to extend the taxonomic theory.

The publication of the book ‘new systematics become a landmark in the history of taxonomy.

Thus taxonomy got a new label of biological taxonomy.

By 1955 taxonomy reach such a status that it was called taxonomic explosion.

<u>4th Period (current trends)</u>

New systematics deal exclusively with species.

The present day taxonomic work include all available differences and similarities.

Instead of morphology as an original base, phylogenetic adaptations, embryological patterns, biochemical variations, genetic variabilities and similarities, behavioral characteristics are all applicable to taxonomic study.

Lecture 4

Species concept

Cuvier in 1829 defined species as 'The assemblage descended from one another or from common parents and of those who resemble one another.

Typological species concept

According to this species concept the observed diversity of the universe reflects the existence of a limited number of underline 'universals' or 'types'.

Individuals do not stand in any special relation to each other being merely expressions of the same type.

Variation is considered as irrelevant phenomena.

This species concept was the concept of Linnaeus and his followers but it goes back to the philosophy of Aristotle and Plato.

This species concept is called essentialistic species concept. According to this concept species can be recognized by their essential characters and these are expressed in their morphology.

It is also called morphological species concept.

Postulates

1. Species consists of similar individuals.
2. Each species is separated from all the other by sharp discontinuity.
3. Each species is constant through time.
4. There are strict limits to possible variations within any one species.

Criticism

1. The concept is rejected because of two practical reasons
2. Individuals are frequently found in nature that are clearly conspecific in spite of striking difference resulting from sexual dimorphism, age and polymorphism.
3. There are species in nature that differ hardly in morphology but are reproductively isolated.

Nominalistic species concept

This concept was popular in France in 18th century but surprisingly it is still used very rarely by some botanists.

They believe that only individuals exist while species are man's own creation.

According to this concept 'Nature produces only individuals and nothing more. They are mental concepts that have been created to refer to great number of individuals collectively.

Criticism

1. No biologist can agree that the species is man- made.
2. It is now an established fact that they are products of evolution.
3. The basic drawback s of the concept was the misinterpretation of the relation between similarity and relationship.
4. Members of a species are similar to each other because of common descend. It is not true that they belong to this taxon because they are similar as claimed by this concept.

Biological species concept

This concept was introduced by Mayr. According to this concept "Species are group of interbreeding natural populations that are reproductively isolated from other such groups"

Thus this species has three separate functions.

1. Members of a species form a reproductive community that is individuals of a species recognized each other as potential mates.
2. Species is an ecological unit that interacts as a unit with other species which shares its environment"
3. Species is a genetic unit that consists of a large gene pool where as an individual is merely a temporary vessel holding a small portion of a gene.

DIFFICULTIES IN APPLICATION OF BIOOGICAL SPECIES CONCEPT

1... Insufficient information: Individual variations in all its forms often raises the doubt whether a certain morph type is a separate species or only a phenon within a variable population.

Organisms may look different and yet be the same species. For example, look at these ants. You might think that they are distantly related species. In fact, they are sisters—two ants of the species *Pheidole barbata*, fulfilling different roles in the same colony.

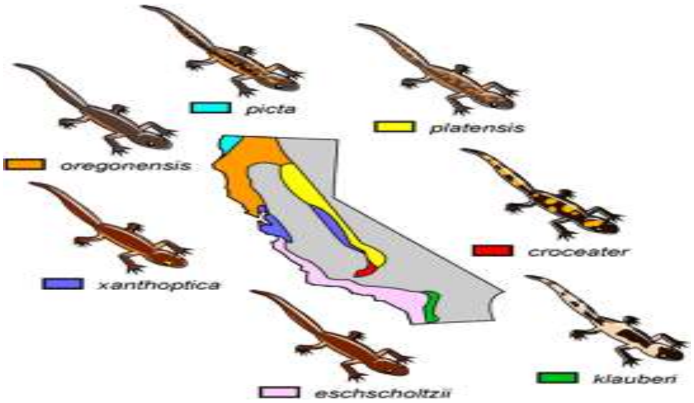
2... Uniparental Reproduction Asexual groups do not fulfill the criteria of interbreeding which is the foremost characteristic of biological species concept.

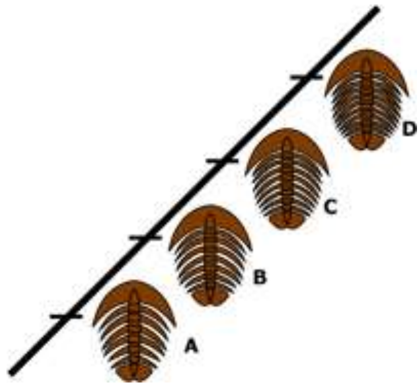
Asexual reproduction is frequent among lower invertebrates with parthenogenesis occurring even in insects, lower vertebrates up to reptiles.

3... Evolutionary Intermediacy Organisms may appear to be alike and be different species. For example, Western meadowlarks (*Sturnella neglecta*) and Eastern meadowlarks (*Sturnella magna*) look almost identical to one another, yet do not interbreed with each other—thus, they are separate species according to this definition.

Ring species are species with a geographic distribution that forms a ring and overlaps at the ends. The many subspecies of *Ensatina* salamanders in California exhibit morphological and genetic differences all along their range. They all interbreed with their immediate neighbors with one exception: where the extreme ends of the range overlap in Southern California, *E. klauberi* and *E. eschscholtzii* do not interbreed. So where do we mark the point of speciation?

Chronospecies are different stages in the same evolving lineage that existed at different points in time. Obviously, chronospecies present a problem for the biological species concept—for example, it is not really possible (or very meaningful!) to figure out whether a trilobite living 300 million years ago would have interbred with its ancestor living 310 million years ago.





4… The occasional breakdown of isolated mechanism

Reproductive isolation may breakdown even among good species. Usually this lead to the production of occasional hybrids which are either sterile or of low viability and so do not cause any taxonomic difficulty. E.g. Mules and hinny.

(Male) donkey x (female) horse = mule

(Male) horse x (female) donkey = hinny

Lecture 5

TAXONOMIC CATEGORIES

Hierarchy: In classification the system of ranks which indicates the categorical level of various taxa (i.e ,kingdom to species). Taxonomic category designate rank or level in hierarchic classification.

The Linnaean hierarchy

Linnaeus was the first taxonomist to establish a definite hierarchy of taxonomic categories.

He recognized only five category within the animal kingdom. i.e. class, order ,genus, species, varieties.

Two additional categories were soon generally adopted when the number of known animals grew – making finer division necessary: the family (between genus and order) and the phylum (between class and kingdom).

The varieties, used by Linnaeus as an optional category for various types of infraspecific variants was eventually discarded or replaced by the subspecies.

Any given species thus belong to seven obligatory categories as follows:

	Wolf	Honey bee
Kingdom	Animalia	Animalia
Phylum	Chordata	Arthropoda
Class	Mammalia	Insecta
Order	Carnivora	Hymenoptera
Family	Canidae	Apidae
Genus	Canis	Apis

Species C.lupus A.mellifera

As the number of known species increased, the need arose for a more precise indication of the taxonomic position of species. This was accomplished by splitting the original seven basic categories and inserting additional ones among them.

The most frequently used additional new category name is the term tribe for a category between genus and family. Vertebrate paleontologists also used the category cohort between order and class.

The generally accepted categories are the folowing:

1. Kingdom
2. Phylum
3. Subphylum
4. Superclass
5. Class
6. Subclass
7. Cohort
8. Superorder
9. Order
10. Suborder
11. Superfamily
12. Family
13. Subfamily
14. Tribe
15. Genus
16. Subgenus
17. Species
18. Subspecies

Taxonomic category

It is a class into which are placed all the taxa that rank at the same level in a hierarchic classification.

Species is a lower category and from the genus up are higher categories.

Taxa are based on zoological realities, categories are based on concepts. In that respect there is no difference between the category species and the higher categories. In many other respects there is a great deal of difference between the concept of the species and the concept of the higher categories.

The category species is "self-operationally" defined by the testing of isolating mechanisms in nature.

The species category signifies singularity, distinctness, and difference, while the higher categories have the function of grouping and ordering by not emphasizing differences between species rather by emphasizing affinities among group of species.

Even though an operational definition for the higher categories does not exist, nor for the rank which they signify, they do have an objective basis because a taxon placed in the higher category is natural consisting of descendants from a common ancestor.

Lecture 6

ZOOLOGICAl NOMENCLATURE

Zoological nomenclature is the system of scientific names applied to taxonomic units of animals (taxa, taxon), known to occur in nature ,whether living or extinct.

The term nomenclature comes from latin words : Nomen -------Names , Calare -------to call

And means literally to call by name

Important requisite of taxa names

Three important requisites should be kept in mind before giving any name to a taxon.

- Uniqueness – name should be unique
- Universality – name should be name all over the world
- Stability – name should not be changed

The international code of zoological nomenclature ICZN

A set of rules for naming of animals and for resolution of nomenclatural problems is called the international code of zoological nomenclature.

After 1800 all the authors adapted Linnaean system-change existing names if they had not been correctly formed which resulted in nomenclatural confusion. So a need for definite rules or code arose

The first set of rules were presented in the first international congress of zoology in 1889.

The code consists of three main parts

- The code proper
- Appendices – a section giving extra information at the end of the book
- Glossary – a list of technical or special words, especially those in the particular text, explaining their meanings.

Code proper

Preamble –an introduction to a book or written document. 90 articles are grouped in 18 chapters. Each article is composed of one or more mandatory provision which are followed by recommendations and illustrative examples. The use of recommendation is not mandatory

Evolution of theory of nomenclature

Changes occur in the basic concept of taxonomy like

- Concept of taxa should refer to a population rather than type
- The nature of type as name bearer only on the basis of which a specie might be named.
- Categorical status of infraspecific names. The sub-species names should be hierarchal in accordance to the specie name

The rules should be adjusted to the conceptual development of taxonomy.

Different needs in different groups---

Parasitologist must make tentative assignment of stages in the life cycle of parasites

Paleontologist may form genera until the true taxonomic status of the taxon is established

Principle of binominal nomenclature

This is the principle that the scientific name of a species, and not of a taxon at any other rank, is a combination of two names; the use of a trinomen for the name of a subspecies and of uninominal names for taxa above the species group is in accord with this principle.

Example house mouse

Kingdom----Animalia

Phylum-----Chordata

Class-------Mammalia

Order-------Rodentia

Family------Muridae

Genus------*Mus*

Species ----*M. musculus Linaeus,1758*

Subspecies

Mus musculus bactrianus, Mus musculus castaneus, Mus musculus domesticus, Mus musculus gentilulus, Mus musculus musculus.

The subspecie whose specific and subspecific names are similar is called as nominate subspecie.

Synonym:

In zoological nomenclature, synonyms are different scientific names that pertain to the same taxon, for example two names for the same species. The rule of zoological nomenclature is that the first name to be published is the senior synonym; any others are junior synonyms and should not be used.

X Antilocapra anteflexa ___ 1855

Species A ……. synonyms *example* Pronghorn synonyms

Y Antilocapra americana --- 1815

For example, John Edward Gray published the name *Antilocapra anteflexa* in 1855 for a species of pronghorn, based on a pair of horns. However, it is now thought that his specimen was an unusual individual of the species *Antilocapra americana* published by George Ord in 1815. Ord's name thus takes priority, with *Antilocapra anteflexa* being a junior subjective synonym.

Homonym:

In nomenclature, one or two or more identical but independently proposed names for the same or different taxa are called homonym. A homonym is a name for a taxon that is identical in spelling to another such name that belongs to a different taxon.

The rule in the International Code of Zoological Nomenclature is that the first such name to be published is the senior homonym and is to be used (it is "valid"); any others are junior homonyms and must be replaced with new names. It is, however, possible that if a senior homonym is ancient, and not in "prevailing usage," it may be declared a nomen oblitum and rendered unavailable, while the junior homonym is preserved as a nomen protectum.

For example: Cuvier proposed the genus Echidna in 1797 for the spiny anteater. However, Forster had already published the name Echidna in 1777 for a genus of moray eels. Forster's use thus has priority, with Cuvier's being a junior homonym. Illiger published the replacement name Tachyglossus in 1811.

Species A ---- X ------ 1779

-------- homonym

Species B ---- X ------ 1907

Moray eel --- Echidna ---1777 (Johan Reinhold forster)

-------- homonym

Spiny anteater --- Echidna --- 1797 (George cuvier)

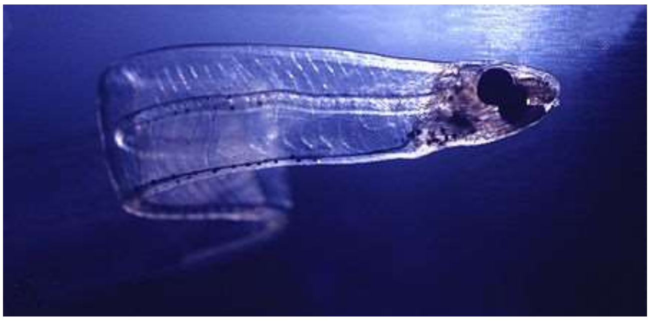
 

Principle of Priority

Principle of Priority is one of the guiding principles of the *International Code of Zoological Nomenclature*, defined by Article 23. It states that the correct formal scientific name for an animal taxon, the name that is to be used, called the valid name, is the oldest available name that applies to it.

It is the most important principle that preserve stability of zoological nomenclature. It was first formulated in 1842 by a committee appointed by the British Association to consider the rules of zoological nomenclature.

Example: Nunneley 1837 give a name *Limax maculatus to a species belonging to* Gastropoda(slug), Wiktor 2001 classified it as a junior synonym of *Limax maximus* Linnæus 1758. *Limax maximus* was established first, so *Limax maximus* takes precedence over *Limax maculatus* and must be used for the species.



In 1856, Johann Jakob Kaup published the name *Leptocephalus brevirostris* for a new species of eel. However, it was realized in 1893 that the organism described by Kaup was in fact the juvenile form of the European eel . The European eel was named *Muraena anguilla* by Carolus Linnaeus in 1758. So *Muraena anguilla* is the name to be used for the species, and *Leptocephalus brevirostris* must be considered as a junior synonym and not be used. Today the European eel is classified in the genus *Anguilla* Garsault, 1764, so its currently used name is *Anguilla anguilla* (Linnaeus, 1758).

First revisor principle

The Principle of the First Reviser deals with situations that cannot be resolved by priority, namely where there are two or more items that have the same date of publication (or the same year of publication when no details are known). These items may be two or more different names for the same taxon, two or more names with the same spelling used for different taxa, two or more different spellings of a particular name, etc. In such cases the first subsequent author who deals with the matter, makes a choice and publishes the decision in the required manner, the First Reviser, is to be followed. [Art. 24.2].

Example: Linnæus 1758 established *Strix scandiaca* and *Strix noctua* (Aves), for which he gave different descriptions and referred to different types, but both taxa later turned out to refer to the same species, the snowy owl. Lönnberg 1931 acted as First Reviser, cited both names and selected *Strix scandiaca* to have precedence.

Principle of Typification

This is the principle that each nominal taxon in the family group or species group has,actually or potentially , a name bearing type fixed to provide the objective standard of refrence by which the application of the name is determined.

This means that any named taxon would have a name bearing type which allow the objective application of that name.

Any family group name must have a type genus , any genus group have a type species and species group name can (not must) have one or more type specimens usually deposited in a museum collection.

Family spheniscidae

1. Aptenodytes

2. Pygoscelis

3. Eudyptula

4. Spheniscus --- type specimen

5. Megadyptes

6. Eudyptes

Holotype: If a nominal species is based on a single specimen that specimen is called holotype.

Syntype: |If a new nominal species has no holotype under the provision of code then all the specimen are of equal value and are called syntypes.

Lectotype: one of a series of syntypes which, subsequent to the publication of the original description, is selected and designated through publication to serve as "the type'.

Paratype: After the holotype has been labelled, each remaining specimens of the type species should be conspiciously called paratype.

Neotype: A specimen selected as type subsequent to the original description in cases where the original types are known to be destroyed or were suppressed by the commission.

Range of authority of code

The code applies to both living and extinct animals. If a still living species was first named on the basis of fossil material,that name is also valid for the living species. If a generic name has been used for a fossil animal,it cannot be used again for a different genus of living animals. There are ,however separate codes for botanical and bacteriological nomenclature.

Key: A tabulation of diagnosstic characters of species (or genera etc) in dichotomous couplets facilitating rapid identification.

Lecture 7

Taxonomic characters

Definition: A taxonomic character is any attribute of a member of a taxon by which it differs or may differ from a member of a different taxon.

A characteristic by which members of two taxa agree but differ from members of a third taxon is a taxonomic character.

Kinds of characters

1. Morphological characters

2. Physiological characters

3. Ecological characters

4. Ethological characters

5. Geographical characters

1. Morphological characters

a. General external morphology
- Plumage of bird
- Pelage of mammals
- scale counts of fishes and reptiles

b. Special structures (e.g. Genetalia):
Difference in genetalic structure has been used to delimit species. It is very effective in insects where lock and key relationship exists between male and female copulatory organs. Color pattern and other aspect of coloration are among the most easily recognized and thus the most convenient characters in certain groups of animals e.g. birds.

C. Internal morphology:
Both the soft as well as hard parts of practically all groups of higher animals have been used as taxonomic characters.

d. Larval stages and embryology:
Various immature or larval stages, the embryology and sometimes even the eggs may provide taxonomic information. E.g. the various sibling species of the *Anopheles maculipenis* complex were discovered owing to differences in egg structure.

The classification of white flies is based primarily on the pupae. Comparative studies of embryological characters like cleavage pattern, blastulation and gastrulation are also useful in certain phyla.

E. Karyology:

Karyology is the description of chromosome structure, size, shape and number etc. Chromosomes are particularly useful on two different levels

- They aid in the comparison of closely related species, including sibling species. These are often far more different chromosomally than in their external morphology.
- Chromosomal patterns are of extreme importance in establishing phyletic lines.

2. Physiological characters

This group of character is hard to define. All structures are the products of physiological processes and are thus physiological characters. By physiological characters one generally means growth constants, temperature tolerances and the various processes studied by comparative physiologist. These characters cannot be studied in preserved material.

Serology: The proteins of one organism will react more strongly with antibodies to the proteins of a closely related organism than to those of one more distantly related. Sibley analyzed the egg-white proteins of more than 100 species of birds and was able to establish relationship among them.

3. Ecological characters

Every species has its own niche in nature, differing from its nearest relatives in food preference, breeding season and tolerance to various physical factors, resistance to predators, competitors and pathogens and in other ecological factors.

E.g. the larvae of both *Drosophila mulleri* and *aldriachi* live simultaneously in the decaying pulp of the fruits of the cactus *Opuntia lindheimeri.* The two species are markedly specialized in their preference for certain yeast and bacteria.

Similarly tapeworms of man and rodents and ascaris of man and pigs though differ very slightly but can be identified by their host specificity.

Each genus of Galapagos finches is characterized by its utilization of the environment, Geospiza is a ground finch while Camarhynchus is a tree finch.

4. Ethological characters

Behavior is one of the most important sources of taxonomic characters. They are clearly superior to morphological characters in the study of closely related species.

Similarly bioacoustics like matting calls of frogs and toads and crickets are used for species delimitation. Similarly the pattern of the webbing constructed by spiders can be used at various level in classification.

5. Geographical characters

Geographical characters are among the most useful tools for clarifying a confused taxonomic picture and for testing taxonomic hypothesis. The taxonomist is primarily interested in two kinds of geographical characters

(1) General biogeographic patterns, which are especially useful in the arrangement of higher taxa.

(2) The allopatric-sympatric relationship, which is most helpful in determining whether or not two populations are conspecific.

Lecture 8

Taxonomic collection

OUTLINES

- Value of collection
- Purpose of taxonomic collection
- Collecting and research
- Scope of collection
- Where and how to collect
- Contents of collection
- Preservation of specimens
- Labeling

Value of collections

Biological collections are highly valuable for the following reasons:

- Museums are only place where extinct species are preserved.
- Specimens of special historical value.
- Specimens rarely found in any collections.
- Many areas in world are geographically inaccessible.
- A material is of unique value if it forms the basis of published research. It may be needed again for verification of original data or for renewed study in the light of more recent knowledge or by new techniques.

Purpose of scientific collection

For typologically oriented taxonomist a collection was an identification collection. According to current thinking, biological classification is the ordering of populations. Collecting, then, is the sampling of populations. An adequate sample of every population should be collected and preserved.

What is adequate collection?

More material is needed in a species with strong individual and geographical variation than in a uniform species. More material is needed for studies of specific and subspecific characters than of the characters of higher taxa.

Collecting and research

On the whole taxonomists spend only a small fraction of their time on the collecting of new material. Some big expeditions of the nineteenth century gathered material that is still not yet fully worked out.

Scope of collection

Only a few large national museums attempt worldwide coverage in all groups of animals. Most museum are largely restricted to a geographic area and to certain group. Too broad a coverage leads to shallowness and a failure to obtain the depth required for detail studies.

The late admiral H.Lynes who was especially interested in Cisticola .a genus of African warblers with some 40 species, made whole series of collecting trips to nearly every corner of Africa. He combined the collecting of specimens with a detailed study of the ecology, songs and nest construction of the birds. The result was that the genus Cisticola, formerly the despair of the bird taxonomists, is now reasonably well understood.

Where and how to collect?

Any collecting trip must be carefully planned. All possible geographic information must be obtained beforehand, including

- distribution of vegetable types
- altitudes
- seasons
- Means of transportation etc.

A plotting of collecting stations and, in particular a mapping of species distribution will reveal the location of crucial gaps.

If the study of geographic variation is a major objective, the periphery of the range of each species should be given particular attention. This is where geographic isolates occur more frequently. If the species show seasonal variations, the collection should be spaced seasonally.

How to collect?

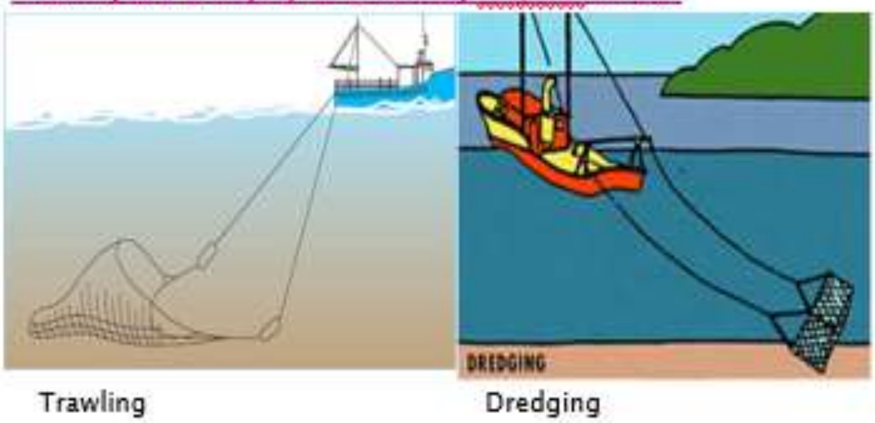
Innumerable techniques for the collecting of different groups of animals are described in standard collecting manuals.

Attracting Nocturnal Insects With UV Light

Insects are collected mainly by beating and sweeping

Aquatic insects and other arthropods are collected by using dipnets .

Trawling and dredging for collecting deepsea animals



Contents of collections.

Preserved specimens are the indispensable basis of all taxonomic research. The information that one can derive from such specimens are limited. The modern systematist needs a great deal of additional information.

As far as possible the collecting should provide unbiased population samples. Not only adult should be collected, but adequate samples of all growth stages (including larvae) and associated parasites. Sampling should be done in such a way as to provide study material not only for the species but also for the evolutionist. Collection of specimens may be augmented by all sorts of recordings including Film of courtship display, Vocalization of animals, Collections or photograph or casts of the work of animals (nests, galls, spider webs etc.)

Preservation of specimens

They differ from one taxonomic group to the next. Some are preserved in alcohol. Some are stuffed. We do not use formalin for preserving arthropods, only vertebrates. Specimens are not kept permanently in f ormalin since it is acidic and difficult to handle. Although generally avoided for long-term storage, formalin may be used in instances where color is important since alcohol dissolves most colors almost immediately. Alcohol is used in long term storage

Labeling

A specimen that is not accurately labeled is worthless for most type of taxonomic research.

RECORDING DATA

- Geographic locality
- Date
- Stage(adult male, female or immature form)
- Altitude or depth.
- Host
- Name of collector

Lecture 9

Intra-population variations

- Non-genetic
- Genetic

Non-genetic

a. Individual variation in time
b. Social variations
c. Ecological variations
d. Traumatic variations

a… Individual variations in time

- Age variations
- Seasonal variations of an individual
- Seasonal variations of generations

Age variations

Animals in general pass through a series of juvenile or larval stages in which they may be quite different from adults.

E.g the immature stages of the eel (Anguilla) were originally described as Leptocephalus brevirostris Kaup.

Similarly the difficulties for the taxonomist are even greater in groups with larval stages which are so different that they have not even the faintest resemblance to the adult (e.g. caterpillar and butterfly)

Seasonal variations of the same individual

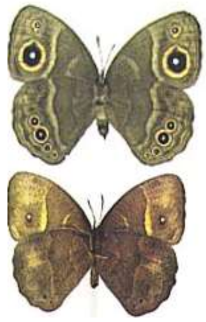
In animals that live as adults through several breeding seasons, it sometimes happens that the same individual has a very different appearance in different parts of the year.

In arctic and subarctic birds such as Ptarmigans, there may be a change from a white winter dress to a normally colored summer dress.

In the European starling (Sturnus vulgaris) the freshly molted bird of October is covered with white spots and all the feathers show whitish margins. During winter the edges of the feathers wears off, and in the spring, at the beginning of the breeding season, the whole bird is a beautiful glossy black without the molt of a single feather.

Rock ptarmigan *Lagopus muta* Montin, 1781
Summer: grey and brown upperparts;
winter: white plumage

Wet season form



Seasonal variation of consecutive generations

These variations are called polyphenism. E.g. African butterfly Bicyclus anynana

Wet season form --- eyespots along the margin (on ventral side)

Dry season form – very small or almost no eyespots

B…Social variations

In social insects like honey bees there are definite groups of individuals within a colony in addition to the reproductive castes (Queen and males or drones), workers and soldiers. The drones are the males in a bee colony. They are the product of unfertilized eggs. The queen is one of many females in the colony; however, she is the only one that is developed specifically for laying eggs. The queen is the product of a fertilized egg that is fed an abundance of royal jelly during its development. They are all females and, thus, come from fertilized eggs. The workers are the majority of the population of the colony. There are about 2,000 to 60,000 workers per colony

C…Ecological variations

- Habitat variation
- Variation induced by temporary climatic conditions
- Host-determined variations
- Density dependent variations
- Allometric variation
- Neurogenic color variations

Habitat variations

Populations of a single species that that occur in different habitats in the same region are often visibly different.

Dall gave a very instructive account of all the variations he observed in a study of the oyster (Crassostrea virginica)

When a specimen grows in still water, it tends to assume a more rounded or broader form.

When it grows in a strong current the valves become narrow and elongated, usually also quite straight.

When an oyster grows in clean water on a pebble, which raises it slightly above the bottom level, the lower valve is usually deep and more or less sharply radially ribbed acquiring thus a strength which is not needed when the attachment is to a perfectly flat surface which acts as a shield on that side of the shell. For the same reas on oysters which lie in a muddy bottom with only parts of the valve s above the surface, are less commonly ribbed.

Variations induced by temporary climatic conditions

Some animals with a highly plastic phenotype may produce year classes that differ visibly from the norm owing to unusual conditions (drought, cold, food supply)

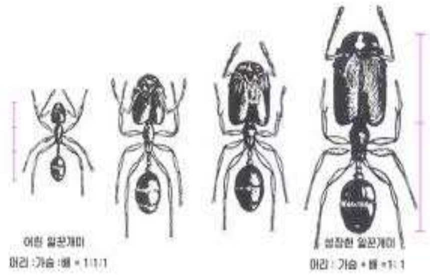
Host-determined variations

Gerould has reported that the braconid wasp Apanteles flaviconchae, spins white cocoons when reared from blue-green caterpillars of Coliase philodice, but golden cocoons when reared from yellow-green caterpillars from the same species.

Density-dependent variations

Kennedy and others have shown that gregarious species of locusts exist in various unstable biological phases. These phases differ in anatomy, color and behavior characteristics and have often been described as distinct species. When newly hatched nymphs are reared under crowded conditions, they mostly developed into the gregarious phase. Under less crowded conditions into the transitional phase and when isolated and reared separately, into the solitary phase.

Allometric variations



Allometric growth result in the disproportionate size of some structure in relation to that of the rest of the body. If individuals of a population show Allometric growth, animals of different size will show allometric variability.

Neurogenic or neuro-homoral variations

Neurogenic variation is color change in response to the environment. Chameleons have specialized cells, chromatophores, which contain pigments in their cytoplasm, in three layers below their transparent outer skin: The chromatophores in the upper layer, called xanthophores and erythrophores, contain yellow and red pigments, respectively. Below the chromatophores is a second layer of chromatophores called iridophores or guanophores; these contain guanine, appearing blue or white. The deepest layer of chromatophores, called melanophores, contain the dark pigment melanin, which controls how much light is reflected. Chameleon change color in reaction to temperature as well as to camouflage. Different chameleon species are able to vary their coloration and pattern through combinations of pink, blue, red, orange, green, black, brown, light blue, yellow and purple

Traumatic Variation

1. Accidental and teratological variations

In most animals it may be readily identified. However, in those forms which undergo metamorphosis, injuries to an earlier stage may produce later abnormalities which are not so easily recognized as such. This is especially true when the anomalies involve characters which are normally of taxonomic value in the group concerned. E.g. symmetrical modification of wing pattern.

Post-mortem changes

In many group of animals it is impossible to prevent post-mortem changes of preserved specimens. Some extreme cases are known in birds. E.g. deep orange yellow plumes of twelve-wire birds of paradise (Seleucidis ignotus) fade in collection to white

Skin of Chinese jay (Kitta chinensis) whose plumage is green in life, turn blue in collections due to chemical action of preservative: Wasp overexposed to cyanide turn bright red

Genetic variations

- Sex-associated variations

- non sex-associated variations

Sex-associated variations

- Primary sex differences
- Secondary sex differences
- Alternating generations

Primary sex differences:

These are differences involving the primary sex organs utilized in reproduction. They are rarely a source of taxonomic confusion

Secondary sex differences:

Sexual dimorphism, in some cases male and female are strikingly different from one another

Examples King parrot Eclectus roratus (Male= green with an orange bill, Female= red and blue with black bills).The two sexes were considered different species for nearly one hundred years until naturalist proved conclusively that they belonged together

Alternating generations

In aphids the parthenogenetic wingless females are usually different from the winged female of the sexual generations.

Non-sex associated variations

- continuous variations
- Non-continuous variations

Continuous variations

Continuous variation is the result of slight genetic differences which exist between individuals.

-it is now evident that no one individual is "typical" of the characters of a populations. Only the statistics of the whole population can give a true picture of the population. 114 species of the snail genus melania were found to be nothing but individual variants.

Discontinuous variations

In certain species, the members of a population can be grouped into very definite classes, determined by the presence of certain conspicuous characters. Such discontinuous variations is called polymorphism. Common alfalfa butterfly ---Coliase eurytheme—has two strikingly different female forms-one resembling the orange colored male while the other is largely white