

UNIT I: BASICS OF ANIMAL CLASSIFICATION

SEM-I ZOOA-CCI-I-TH; TAXONOMY, TYPES, SYSTEMICS;

Definition of Taxonomy:

The term taxonomy is derived from two Greek words – taxis meaning arrangement, and nomos meaning law. It was first proposed in 1813 by A.P. de Candolle (a professor of Montpellier University in France) in its French form, for the theory of plant classification. “Taxonomy is the theoretical study of classification, including its bases, principles, procedures and rules”. According to Mayr (1982), “Taxonomy is the theory and practice of classifying organisms”.

Taxonomy is thus an information system comprising of classification, nomenclature, descriptions and identification.

According to Christoffersen (1995), taxonomy has become the most basic activity in biology, dealing exclusively with the discovery, ordering and communication of patterns of biological taxa. It, however, leans heavily on systematics for its concepts.

Scope of Taxonomy:

The scope of taxonomy and that of systematics in particular are:

1. It works out a vivid picture of the existing organic diversity of our earth and is the only science that does so.
2. It provides much of the information, making it possible for the reconstruction of the phylogeny of life.
3. It reveals various interesting evolutionary phenomena, making them available for casual study by other branches of biology.
4. Almost entirely, it supplies information needed by the various branches of biology.
5. It provides names for each kind of organism, so that all concerned can know what they are talking about and such information can be recorded, stored and retrieved when needed.
6. It differentiates the various kinds of organisms and points out their characteristics through descriptions, keys, illustrations etc.
7. It provides classification, which are of great heuristic and explanatory values in most branches of biology like evolutionary biochemistry, immunology, ecology, genetics, ethology, historical geology etc.
8. It is important in the study of economically or medically important organisms.
9. It makes important conceptual contributions in population thinking, thereby making it accessible to experimental biologists. It thus contributes significantly

to the broadening of biology and to a better balance within biological science as a whole.

Levels of Taxonomy:

α (alpha), β (beta) and γ (gamma) taxonomy:

There are three phases of taxonomy symbolized as α (alpha), β (beta) and γ (gamma) taxonomy:

Alpha (α) taxonomy:

Alpha (α) taxonomy is the analytic phase in which the species are identified, characterised and named. At this level when a new species is discovered it is named in accordance with Linnaeus system of binomial nomenclature. Here priority is given to the one who publishes his work first. All problems relating to species are dealt here.

Beta (β) taxonomy:

Beta (β) taxonomy refers to the arrangement of the species into a natural system of hierarchial categories. This is done on the basis of easily observable, shared, structural features and evaluation of numerous characters. Thus, β -taxonomy relates to the search of a natural system of classification. Each taxon would thus possess diagnostic features unique to that taxon.

Gamma (γ) taxonomy:

Finally, gamma (γ) taxonomy designates the analysis of intraspecific variations and evolutionary studies. Much

attention is paid to a causal interpretation of organic diversity — study of speciation. But in actual practice it is rather difficult to dissociate them because these overlap and integrate.

There are only a few groups of animals (some vertebrates, especially the birds and a few insect orders like Lepidoptera etc.) where the taxonomy has reached up to the gamma level. Otherwise, in almost majority of the groups, the Works are still at the alpha and beta level.

Definition of Systematics:

The term systematics originated from the Latinized Greek word **systema, meaning to put together**. It was used by Linnaeus for the systems of classification, in the 4th edition of his book **Systema Naturae in 1735**.

Simpson (1961) defined the term systematics as “the scientific study of the kinds and diversity of organisms and of any and all relationships among them”. More simply, systematics can be defined as **“the science of the diversity of organisms”**.

In the above definition, the word “relationships” is to be understood not in any particular, narrow phylogenetic sense, but in a fully general way, including all biological interactions among organisms. The activity of systematics in studying relationships among kinds of organisms almost necessarily requires the erection of some formal system in which the organisms in question

are grouped into classes and of a vocabulary by which those classes are designated.

Thus, it involves Classification and Nomenclature.

Zoological classifications are the ordering of animals into groups (or sets) on the basis of their relationships or of associations by contiguity, similarity or both.

Zoological nomenclature is the application of distinctive names to each of the groups recognized in any given zoological classification.

Systematics is thus taxonomy plus the biological interrelations—breeding systems and genetics, phylogeny and evolutionary processes, biogeography and synecology. It is evident that all comparative biological sciences (comparative anatomy, comparative physiology etc.) enter into systematics as they study relationships among diverse organisms.

The relevance of **biogeography** to systematics is generally recognised, at least implicitly. For example, Mayr's (1942) "Systematics and the origin of species" employs Zoogeographical data throughout. Also, Darlington's (1957) "Zoogeography: The geographical distribution of animals" includes at least as much work in systematics as on geography.

The relevance of **synecology (the study of multi-specific communities)** as a branch of systematics is due to the study of relationships among diverse organisms.

Autecology (the study of the relationships between particular kinds of organisms and their environments), is less directly connected with systematics, but when studied comparatively it plays the same role as other comparative biological studies in providing data for systematics, mainly in the form of associations of similarity, which is essential in the study of convergence. Genetics also is closely allied to systematics. The species problem, one of the major focus of attention in systematics, is fundamentally a genetic problem.

Place of Systematics in Biology:

1. One of the major preoccupations of systematics is to determine by comparison, what the unique properties of every species and higher taxon are?
2. It determines what properties certain taxa have in common with each other and what the biological causes for the difference or shared characters are?
3. It concerns itself with variation within taxa.

Due to the above, systematics holds a unique and indispensable position among the biological sciences. This accessibility of organic diversity is made possible due to classification. Systematics deals with population, species and higher taxa.

No other branch of biology occupies itself in a similar manner with such level of integration in the organic world. It not only supplies urgently needed information

about these levels but, more important, it cultivates a way of thinking, a way of approaching biological problems, which is tremendously important for the balance and well-being of biology as a whole.

Contribution of Systematics to Biology:

There is immense contribution of systematics to other branches of biology and to humankind as a whole. The study of organic diversity, prior to the rise of genetics, was entirely carried out by systematists. Virtually all major evolutionary problems were brought to the forefront and solved by systematists and even today new evolutionary problems are revealed by them. A similar dependence on systematics exists in other areas of science.

Some of the noteworthy contributions are:

A. Patterned Diversity:

Organic diversity is not chaotic but patterned, revealing all sorts of regularities. The task of the systematics is to discover the true nature and causation of these patterns. Rodents and lagomorphs (rabbit etc.) have rootless gnawing incisors.

It is the task of the systematists to find out the reasons behind the causation of such similarity. Is it due to common descent or due to adaptation to an equivalent adapting zone? All evolutionary processes or

phenomenon can only be studied reliably if a sound taxonomic foundation is present.

B. Applied Biology:

The contribution of systematics, both directly and indirectly, has been noticed in applied sciences like medicine, public health, agriculture, conservation, management of natural sources etc.

(a) Epidemiology:

The famous case of epidemiology of malaria, caused by *Anopheles maculipennis*, was reported throughout Europe, yet malaria was restricted to local districts. Large amounts of money were wasted and yet no one understood the connection between the distribution of the mosquito and that of malaria. Finally, the key to the problem was provided by systematics.

A. maculipennis was found to have a number of sibling species with different habitat preferences and breeding habits. Only some of the *maculipennis* complex was responsible for the transmission of malaria and that too in a given area. This information allowed control measures to be directed to those spots where they were effective.

(b) Biological Control:

Another example is the biological control of insect pests. For a brief period it appeared that biological control had

become obsolete owing to the success of chemicals (pesticides etc.), Because of the adverse effect of these chemicals on human health applied entomologists had to revert increasingly to biological control.

The work of the taxonomist or systematics is to find out the parasites that attack the various pests (and at which stage of the pest) and thereby the application of these parasites can bring about a successful control of these pests.

(c) Wildlife Management:

We are aware that deforestation and indiscriminate killing of animals have resulted in dis-balance of nature. Many species of plants and animals have become extinct and many are on the road to extinction. Taxonomists have contributed to environmental protection by identifying all such endangered plants and animals that are endangered due to anthropogenic causes.

(d) Determination of sequential events:

Dating of rocks is generally done through radioactive decay, but sedentary rocks can be dated through their enclosed flora and fauna. The taxonomist plays a vital role by identifying such flora and fauna and formulating a clear picture of the geological events. Such work has often been of great value, particularly in the success of oil industries in America.

(e) Environmental problems:

Various environmental problems have been successfully tackled by systematists. Environmental problems such as pollution, leads to the persistence of certain non-biodegradable pollutants in the environment. Tracing the movement of these pollutants in the food chain requires the identification of the various species that constitute the biotic community.

Present advances in systematics have revealed that various species of plants and animals act as indicators of pollution. The identification of such species in a particular location helps in the rapid and inexpensive monitoring of the pollutants that degrade the concerned environment.

(f) Soil fertility:

Many animals and microbes play important role in increasing soil fertility. It is essential to locate such species and detect the role they play in soil fertility, so that such species can be utilised in agricultural management practices.

(g) Introduction of commercially important species:

Based on sound systematics various commercially important species have been established in India and other countries. Correct identification of such species and the role they play in the ecosystem provides useful information for their introduction.

Apis mellifera (the Italian honey bee), *Cyprinus carpio* (common carp) etc. are some exotic species that have been successfully introduced in India. This has been made possible only through correct identification by the systematists.

C. Theoretical Biology:

Population thinking has come into biology due to taxonomy and systematics. One of the two roots of population genetics is systematics. The problem of multiplication of species was solved by them.

It was systematics who continued to uphold the importance of natural selection when early Mendelian's thought that mutation had eliminated the role of natural selection as an evolutionary understanding of mimicry, provided the first clear proof of the importance of natural selection in evolution.

The development of ethology and the study of the phylogeny of behaviour were developed by the taxonomist and naturalists. Thus, systematics have contributed to a healthy balance in biological science.

History of Taxonomy:

The development of a scientific theory of classification is probably a recent phenomenon. There is no doubt that **Aristotle (384-322 B.C.) was the father of classification.** According to Aristotle "Animals may be characterised according to the way of living, their actions, their

habitats and their bodily parts”. He referred to such major groups of animals like birds, fishes, whales and insects.

He used differentiating characters such as blooded versus bloodless, two-footed versus four-footed, hairy versus feathered etc. Although Aristotle’s thinking dominated animal classification for the next 2,000 years, nevertheless he failed to supply an orderly, fully consistent classification.

Concepts of Taxonomy:

In 1975 Mayr and Ashlock first put forward the concept of Micro-taxonomy. Development of the debates on the species, centering mainly around the so-called biological species concept, was called micro-taxonomy or the science of species by Mayr (1982).

One of the major problems of micro-taxonomy evolves around the concept of species. A merging of different research traditions, in systematics as well as in palaeontology and genetics, prompted the development of micro-taxonomy.

Micro-taxonomy involves the study of concepts of species like Typological species concept, Nominalistic species concept, biological species concept, Evolutionary species concept etc.

Micro-taxonomy deals with problems like the evolution of species, estimation of the population of species in the

living world or in special groups of organisms to which any two, three or all species definitions apply.

It also deals with geographic variation, the recognition of polytypic species, the definition of subspecies and species, the taxonomic status of incipient species and the role of non-morphological characters in the delimitation of species. In any case, the biological distinction is primary and the morphological difference secondary.

Macro-taxonomy is the science of classification which deals with taxonomy of larger biological units (as family, order, class).

Theoretical comments ranged from a denial that supra-specific taxa were natural entities, to vague statements that a phylogenetic classification is the more natural. How do we reconstruct phylogeny? How do we represent it in a formal classification? These were the problems being dealt under macro-taxonomy.

Macro-taxonomy involves study of homology, analogy, affinities, systematic status and phylogeny.

Micro-taxonomy and Macro-taxonomy are related in the sense that one is incomplete without the other. For the science of classification of species it is very important to know the science of species. Macro-taxonomy involves the establishment of equivalent basis of their features. So how is grouping (Macro-taxonomy) possible without

knowing the features of the object (Micro-taxonomy). Hence one is heavily dependent on the other.

Modern Trends in Taxonomy:

The term new or modern is a relative term, as what is considered new or modern today may become old systematics in the future. The new systematics introduced by Huxley in 1940 may indeed be very old systematics today. To dispel such misinterpretation of new systematics the words of Mayr (1964) is of immense help.

Mayr wrote “What then is the new systematics? Perhaps it is best described as a view-point, an attitude, a general philosophy. It started primarily as a rebellion against the nominalistic typological and thoroughly non-biological approach of certain, alas all too many, taxonomists of the preceding period”.

The New Taxonomy, thus, is an approach of the population taxonomists that differ drastically from the simple pigeonholing of classical Linnaean taxonomy. Workers in the new systematics consider themselves biologists rather than filing clerks.

New Taxonomy is neither a special technique nor a special method but an attitude which can be applied at every taxonomic level. It deals with –

1. The utilisation of an ever-increasing number of characters and a continued depreciation of key characters — in contrast to the typological approach.

2. A ready acceptance of new tools and techniques such as —

- (a) Visual analysis of sounds in insects, frogs and birds,
- (b) Analysis of courtship displays and other behaviour,
- (c) Utilisation of biochemical characters,
- (d) Utilisation of computers.

3. A further clarification of concepts, such as

- (a) Clear separation of taxon from categories,
- (b) Recognition of the subspecies as a category and not as an evolutionary unit, and
- (c) Clean understanding of the causes of similarities and differences between taxa.