The Importance of Systematics

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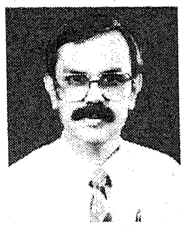

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Systematics or taxonomy, the science of classifying living organisms (see *Box* 1), is still a neglected field in India, as compared to most developed countries. In fact, there is a common perception that taxonomy is an outdated and less important field of biological research involving mostly cataloguing of species. As a result of the neglect of taxonomy in India, our fauna and flora have largely been studied by European and American specialists, and often we have to pay foreign agencies for the identification of our own species (see also Project Lifescape – Part 1, *Resonance* 4 (8): 80-90; 1999).

Systematics and its Relevance

Before starting any kind of biological research, one needs to know the correct scientific name of the organism on which one is going to work. This is important because the correct scientific name of the organism is a functional label, using which various pieces of information concerning that organism, including all the past work done on it, can be retrieved and stored ensuring ease of reference. Systematics has great relevance to the biological control of pests which is itself a very important aspect of applied biology. When natural enemies are being sought or transferred from one region to another, in order to bring about biological control of a pest, the correct identification of both the pest and natural enemy species is of utmost importance. Taxonomists through their research and assistance can help biological control workers by:

1. Providing correct identification of pest species and information on its probable home.
2. Directing and conducting surveys for natural enemies existing in the original home of the pest.
3. Making an inventory of natural enemies and alternative hosts of the natural enemies in the country of introduction.

This paper is based on a scientific lecture delivered by the author on 18th February 1999 at the Centre for Ecological Sciences, Indian Institute of Science, Bangalore.

Box 1. Systematics, Taxonomy and Classification

Very often, the terms systematics and taxonomy are used interchangeably to refer to the science of classification per se (this is the restricted sense in which systematics is used in most of this article). However, many eminent workers in the field, most notably George Gaylord Simpson and Ernst Mayr, have preferred to interpret systematics more broadly as the scientific study of the kinds and diversity of organisms and of any and all relationships between them. These workers believe that taxonomy (a word coined by the French botanist A P de Candolle in the 19th century) should be used to refer to the study of the bases, principles, procedures and rules of classification, and that the term classification should be used for the practical application of taxonomy to particular groups of organisms. In their view, systematics is more than the science of classification, and encompasses studies on ecology, evolution and biodiversity. Thus, some workers feel that the aims of systematics can be summarized as follows.

(a) To provide a convenient method of identification and communication.

(b) To provide a classification that expresses, as far as possible, the natural relationships of organisms.

(c) To detect evolution at work, discovering its processes and interpreting its results.

4. Providing catalogues, revisions, hand-books, keys, etc.

Systematics also has relevance for epidemiology. In order to find remedies for illnesses caused by pathogenic organisms, the correct identification of the pathogen is absolutely essential. Taxonomists contributed greatly to the successful control of malaria in Europe by providing correct identification of the Anopheline species of mosquitoes involved in transmitting the disease causing parasites. Similarly, the work of Nathan Charles Rothschild, a taxonomic authority on flea species, was responsible for the discovery that the geographic distribution of different species of rat fleas in India was one of the most important factors governing the spread of plague. Systematics is also important for understanding factors determining the abundance and diversity of different species making up the living world.

Identification Procedure

It is not possible for a taxonomist to become a specialist in too many groups or families of organisms. An animal taxonomist can expect to be an expert only in a few families or at the most in one or two orders, especially in the case of insects where each order or family is usually represented by innumerable species. A

Box. 2. Modern Methodologies in Systematics

Just like any other branch of biology, systematics too has benefited greatly from the recent development of techniques for assessing genetic similarities and differences among individuals at greater and greater levels of resolution. Nowadays, in addition to morphological characters, systematists can directly study the genetic composition of different individuals and use this information to refine and revise our understanding of the relationships among various taxa (for more details on reconstruction of evolutionary pathways using genetic data see *Resonance* 3(2): 28-34; 1998). Similarly, with the dramatic increase in computing power in recent times, computation intensive statistical methodologies can now routinely be used to make comparisons of taxa based on hundreds of characters at a time, taking taxonomy closer to the ideal expounded by John Ray in 1682, "All parts of the plant should be used for taxonomic purposes". The use of genetic data for taxonomic purposes also brings systematics closer to realizing Darwin's desire that classification should reflect evolutionary relationships.

taxonomist of a group of organisms will usually have all relevant up to date published literature on the group. He will also have a good representative collection of authentically identified specimens of his group. With these items and with a sound background knowledge on the taxonomy of this group of his specialization, the taxonomist follows the following steps for identifying a specimen sent to him by others.

Systematics is nothing less than a thorough and complete study of the diversity of living forms, and its domain thus encompasses ecology, evolutionary biology and biodiversity studies, in addition to the norms and principles of classification.

Using Taxonomic Keys

A taxonomic key consists of hierarchically arranged diagnostic information that presents alternatives with reference to features of various taxa (a taxon is a taxonomic unit such as species, genus, etc). The main objective of a taxonomic key is to separate and segregate characters in such a way as to provide a series of alternative choices. By comparing an unidentified specimen feature by feature with the key couplets, one gradually eliminates all the non-agreeing subgroups and arrives at the one which agrees. For example, let us assume that there is a genus called A which contains 4 species which are : A-1, A-2, A-3 and A-4.

Now let us assume that we have a specimen that we recognize as belonging to the genus A, but we are unaware of which species it is. We have a dichotomous key available as shown:

1 Antenna longer than the body	2
(this means, go to couplet no. 2)	
= Antenna shorter than the body	3
2 Antenna with clava (club)	A-1
= Antenna without clava	A-4
3 Length of abdomen 3 times length of thorax	A-3
= Length of abdomen 5 times length of thorax	A-2

How do we use this key to identify our specimen? Let us say our specimen has antenna shorter than the body, with abdomen 5 times longer than its thorax. In that case, we look at couplet no. 1, go to couplet no. 3, and find that our specimen belongs to the species A-2. However, if our specimen had antenna shorter than the body, with abdomen shorter than its thorax, then it would run up to couplet no. 3 but would not fit into the description of either species A-2 or A-3. In such case, it is an undescribed or new species; let us name it A-5. Now, an updated or modified key can be prepared in order to accommodate this new species A-5 as follows:

1. Antenna longer than the body	2
= Antenna shorter than the body	3
2. Antenna with a clava	A-1
= Antenna without a clava	A-4
3. Abdomen shorter than thorax	A-5 *sp. nov.*
= Abdomen longer than thorax	4
4. Abdomen 3 times longer than thorax	A-3
= Abdomen 5 times longer than thorax	A-2

The above described keys are known as simple dichotomous keys. There are several modifications of the dichotomous key, but it is still the most popular and easy one to work with.

As a result of our neglect of taxonomic studies, foreigners studied our fauna and because of this we are often dependent on them for identification of our own flora and fauna.

Comparing the identified specimen with previous descriptions: After using the key, if the specimen is identified as belonging to an already known species, then the next step will be to compare

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the specimen, character by character, with the original description (and revised descriptions, if available) of that species. If the specimen agrees well with the available description of that species, then we can conclude that our specimen at hand is, say, A-2. However, if the available descriptions of the species are poor or inadequate, we have to proceed to the next step.

Comparing the identified specimen with authenticated specimens: If an authentically identified reference collection is available, the identifier should compare the identified specimen with the authentically identified specimen(s) of that species for reconfirmation of the identification. It is possible that after identification of a specimen using key and description, there may still be some differences between the identified specimen and the authentically identified specimen of the same species. In such case, a thorough analysis of the characters of the specimen, and a detailed comparison of these characters with the original type specimen of the species is essential for unequivocal identification of the specimen.

Identification of a New Taxon

After identifying a new species, genus or other taxon, the taxonomist prepares a description of the taxon based on certain 'types'. There are various such 'types' in taxonomy, of which the important ones are listed below.

Holotype: It is a single specimen selected by the original author to represent the taxon and so designated or indicated as the 'type' at the time of publication of the original description.

Paratype: After the holotype has been labeled, any remaining specimen(s) of the holotype series can be labeled as paratypes, in order to identify the individuals of the original type series.

Lectotype: If a type series contains more than one specimen and a holotype has not been designated, any subsequent worker may designate one of the specimens as the lectotype.

Syntype: If an author did not designate a holotype or lectotype, but based his original description of a new species on a single specimen or group of specimens, they are known as syntypes.

Neotype: If no holotype, lectotype or syntype is known to exist (or has been lost), then the first reviser of the group may select a specimen fitting the original description of the species fully. A type specimen chosen in this manner is called a neotype.

Naming of New Taxa

For the sake of brevity, our discussion in this section will be restricted to the naming of new species. A general principle of both zoological and botanical nomenclature is that scientific names of species be made up of two words that are in Latin or in latinized form if derived from other languages, such as Greek. The first word in the name is the genus name, and is capitalized, whereas the second word is the species name and is not capitalized. Thus, the scientific name for humans, *Homo sapiens*, identifies us as belonging to the species *sapiens* of the genus *Homo*. Since names must be in latin or in latinized form, the case-ending of the species name must agree grammatically with the generic name. Thus, the descriptive adjective *aureus*, meaning golden, retains its case-ending *-us* if in conjunction with a masculine genus, for example *Epitranus*, but changes to case ending *-a* if the genus is feminine (for example *Brachymeria aurea*) and to case-ending *-um* if the genus name is of neuter gender (for example *Notaspidium aureum*). Some adjectival case-endings are the same with both masculine or feminine generic names, for example *Epitranus chilkensis* (masc.) and *Hockeria keralensis* (fem.).

There are several kinds of names used in taxonomy, as discussed below.

Descriptive names: Such names describe some character of the species, for example '*gigantica*' or '*giganticus*' indicating large size, '*globosa*' indicating round shape, or '*alba*', '*albus*' or '*album*' indicating white colour.

Ecological names: Names can also be assigned according to the

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habitat or habit of the species, for example '*subterraneus*' (living underground) or '*arboricola*' (= tree living), or according to the manner of living such as '*aggregatus*' (living in groups).

Geographical names: Names based on the locality where the type specimen was collected, or on general distribution of species are called geographical names, for example '*arizonae*', '*arizonicus*', or '*arizonensis*'. Geographical names are very useful even if several species of the same genus are known from the same locality since at least the geographical name clearly indicates the original locality or region of the 'type' of the species, or the general distribution of the species. Hence geographical names (and names based on characters) should be given high priority in naming a new species if these names are not already occupied.

Patronymic names: Species names can also be based on the names of eminent persons, or of the person who collected the specimen concerned. In naming a species after the name of a person, the person's name (usually the surname) is taken as the stem of a latin noun, and to this stem a genitive ending is added. These endings are '*i*' in the case of masculine name (example: *nathani* from Nathan, *josephi* from Joseph, etc) and '*ae*' in the case of feminine gender (*sarae* from Sara, etc).

Names without definite meaning: Sometimes latinized names based on arbitrary combinations of letters with or without original meaning (e.g. '*tantana*', '*dantana*', '*posa*', etc) can be used in order to avoid undesirable implications of meaningful names, or in situations where relevant descriptive or geographical names are already occupied.

Apart from the above described categories of names, names based on host organisms, or words of other languages (such as latinized Sanskrit words e.g. '*Tanugatra*' meaning slender body) can also be used. Very long names are inconvenient to work with and should be avoided, as should facetious names, or those likely to cause religious or personal offense.

Synonyms and Homonyms

If more than one name is known for a taxon, all these names are known as synonyms. Among these synonyms, the first published valid name is the senior synonym and the subsequent ones are junior synonyms, of which there are two kinds. Objective synonyms are different names proposed separately for the same specimens, or new names for supposedly preoccupied names. Names that are synonyms only in the opinion of one or a few workers are known as subjective synonyms.

Example: Senior synonym: *Brachymeria lasus* (Walker), 1841

Junior synonym: *Brachymeria punctiventris* (Cameron), 1911.

Homonyms arise when the same name is used for two or more different taxa. Here, too, the senior homonym is the first published valid name.

Example: *X-us karnatakensis* Jones 1950 (senior homonym)

X-us karnatakensis Rao 1960 (junior homonym)

In this example, the senior homonym is valid, and the junior homonym needs a replacement name. As per the code of ethics in systematics, any zoologist who finds out the homonym must, by way of professional etiquette inform the author of the junior homonym (in the above example Rao) and give the said author an opportunity to propose a replacement name. If the said author is not alive, the reviser can propose a name and in that case it will be courteous to name the taxa after the author of the junior homonym, e.g. *X-us raoi* Johns, if Johns is the reviser. In such cases the original author (in this case Rao) of the junior homonym loses the species, since it will be now associated with the name of the reviser (here Johns).

Meaning of Author's Name in Brackets

Typically, a species name is followed by the surname of the describing author, e.g. *Myosotis collina* Hoffmann. Often one comes across scientific names with the author's name in brackets, e.g. *X-us albus* (Smith). If the author's name is in brackets, it indicates that originally the author Smith had described the species in some other genus and not under '*X-us*' and another author later transferred it to '*X-us*'.

Taxonomic Language

Taxonomic descriptions are always made very briefly and succinctly, and words like 'is', 'are', 'the', etc are not generally used. For example: 'The anterior width of the head is two times its anterior length' becomes 'the anterior width of head 2*x* its anterior length'. Similarly 'antenna is ten segmented' becomes 'antenna ten segmented'.

Conclusion

Systematics today is an exciting and active branch of biology and it is to be greatly wished that more students of life sciences take up systematics as their research field. In its broader sense, systematics is nothing less than a thorough and complete study of the diversity of living forms, and its domain thus encompasses ecology, evolutionary biology and biodiversity studies, in addition to the norms and principles of classification.

Suggested Reading

[1] R E Blackwelder, *Taxonomy, A text and reference book*. John Wiley and Sons Inc. New York, 1967.
[2] E Mayr and P D Ashlock, *Principles of Systematic Zoology*, Mc Graw-Hill Inc, New York, 1991.
[3] P H Davis and V H Heywood, *Principles of Angiosperm Taxonomy*, Van Nostrand, Princeton, 1963.

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Please Note

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(second Photo Caption)

Seaborg received the Nobel Prize for Chemistry in 1951 and not in 1987 as printed.