

TEACHING OF TAXONOMY AT UNDERGRADUATE LEVEL IN INDIA

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ABSTRACT

General Introduction

(i) *Denotation of the term taxonomy* as used in the paper—de Candolle's analysis of classificatory procedures in Botany—Empirical and Rational. Further subdivisions of Rational Classification, Practical, Artificial and Natural.

Differences between experimental and classical taxonomy. Since experimental taxonomy is beyond the scope of teaching at initial stages, the teaching of classical taxonomy will be dealt with in the paper. Experimental taxonomy is to be reserved for the post-graduate and research level.

So also detailed study of taxonomy of lower groups of plants shall be set apart for post-graduate and research level. We are mainly concerned here with the teaching of taxonomy of Angiosperms.

(ii) *Importance of teaching taxonomy.* Shortage of trained taxonomists.

(iii) *Present status of taxonomy.* Among the biological subjects how it is neglected. Even in teaching it has become so to say an 'endemic' which may soon get 'fossilised' if not properly nurtured and cared for. The problem is involved.

Suggestions for making teaching of Taxonomy interesting and effective

(i) *Systems of classification to be studied.* At initial level the relative position of only the major taxa, say Monocotyledons, Dicotyledons, Gymnosperms only need be stressed. Only one system need be taught in detail, say that of Bentham & Hooker, which may be easily grasped by beginners. All the post-Darwinian systems may be taught only at higher levels.

(ii) *Mode of teaching.* Students are often bored by complicated morphological terms.

Greater importance should be given to genera and families. But to start with, more importance is to be given to higher taxa, i.e. teaching at first may be from above downwards. Teaching may be from below upwards only at later stages.

(iii) *Excursions.* Short afternoon or one-day trips rather than one long excursion. Excursions should help a thorough study of the flora of small selected areas ; with special reference to ecology.

(iv) *Herbarium.* Importance ; the handicap of the present system of herbarium preparation and submission by degree class students and even by post-graduate students. Submission of herbarium by degree class students may be stopped. Collection and preparation of herbarium by post-graduate students may be so modified and organised that within a few years we may have collected all the plant species of our country.

(v) Not being satisfied by dried herbarium specimens, there should also be Botanical gardens attached to every institutions where teaching of taxonomy is undertaken ; for cultivation of rare plants and also of specimens for class work. Such Botanical gardens at district level and bigger ones at state level should also be maintained.

(vi) *Collection and study of lower groups* of plants should also be promoted. Of these Algae are more important from the point of view of Fisheries and Agriculture. Fungi and Bryophytes also deserve special mention.

(vii) *Model of questions for practical examination in taxonomy.* Some modifications are needed, giving greater importance to major taxa at lower levels.

(viii) Students should be made to appreciate the idea of a happy co-operation between the various branches of biology, say taxonomy and anatomy (especially embryology), taxonomy and cytogenetics, etc.

PART I

GENERAL INTRODUCTION

Taxonomy in the broad sense of the term is the study of the principles and practice of classification, and in this general sense is concerned with a common and fundamental methods of handling information of all sorts, biological and non-biological. In a biological connotation the term was first introduced by the French botanist A. P. de Candolle in 1813. Through usage the term has come to apply parti-

cularly to the methods, principles, and even in part to the results of biological classifications.

De Candolle recognised the following as the methods of classification, viz. *empirical* and *rational*. Of these two, empirical classification is independent of the nature of the objects classified (example is alphabetical classification). On the other hand rational classification has a real connection with the objects classified.

Rational classifications only deserve serious scientific attention. They may be either *practical*,

artificial or *natural*. Practical classification is based on the properties of plants mainly in relation to their value (or otherwise) to the human race. Artificial classifications are designed primarily to facilitate the identification of unknown plants. Natural classification gives expression to the true natural affinities between plants.

Of these, practical classification is only of minor importance. The artificial classification is based exclusively upon the external form, i.e. morphology of plants. Their major groupings are based on one or a very few easily discernible characters. Those which employed the most constant features and which most consistently led to the correct identification of the plant under study are considered to be the most successful. The dichotomous key used by Lamarck in 1778 and the so called sexual system of the great Swedish systematist Carolus Linnaeus are examples.

Linnaeus' system adopted as its basic unit the species which were grouped into genera. In the sexual system genera were grouped simply by reference to a few floral characters after the manner which had already been regularised by the French botanist Tournefort. These groups seemed to possess the appearance of natural units. The existence of such character correlations helped to establish the concept of some form of natural affinity.

The post-Linnean taxonomists rejected the idea that single characters chosen mainly for convenience could supply the basis for a perfect classification and sought to produce groupings in which plants possessing the greatest number of common attributes were placed together. To achieve this, detailed study of every part as far as within their means, was made. They believed that only this exposes true relationships and natural affinities. Thus even before the general acceptance of the idea of organic evolution the idea of natural affinities dawned as a result of plant taxonomic studies.

The rediscovery of laws of heredity, first formulated by the Moravian monk Gregor Mendel in 1865, but unknown to the majority of Biologists until 1900 led to the birth of genetics. This then paved the way for the growth of Cytology. Plant Physiology began to throw light on the genesis of plant form. Simultaneously the new science of Ecology placed stress on plants in their natural environments. The impact of new sciences appeared to reveal the inadequacy of the existing taxonomic systems as a means of expressing conclusions about the interrelationships of plants. Cytologists, geneticists, and ecologists felt this inadequacy of the *Orthodox* (or *pre-Darwinian*) taxonomy of the groups which they had been studying experimentally. Some workers have entirely rejected the basis upon which orthodox taxonomic structure has been founded and have constructed their own system of categories of variation to express their findings, building up various "special purpose" or *Experi-*

mental classifications for the groups which have been studied experimentally.

This has led to the present situation where the orthodox taxonomy has to face the experimental taxonomists who discover explanations for some of the old mysteries and condemn many of the old practices.

At this juncture the question is what the present generation of students of Botany is to pursue in the field of plant taxonomic studies.

Before proceeding further I shall try to bring out the differences between the orthodox and experimental taxonomy as pointed out by J. H. Harrison.

Experimental taxonomy differs from the classical taxonomy in its aim, unit of study, system of classification, source of data, tests of characters, methods of description and concept of natural variation involved. Of these the aim is the most important. The aims of classical taxonomy are to describe all kinds of plants, to classify them according to their resemblances and differences, and to name them according to a body of internationally agreed rules, while the aims of experimental taxonomy are to identify evolutionary units, and by experiment to determine their genetical relationships and the role of the environment in their formation. Experimental taxonomy is actually in large part the study of evolution itself. Classical taxonomy is all embracing, claiming the whole plant kingdom as its sphere. The field of experimental taxonomy is at present limited to a relatively few groups. Orthodox taxonomy employs comparative morphology including comparative anatomy as its primary data source, for this is the only one which can be called upon with reasonable facility throughout plant kingdom.

From what has been said till now it is clear that as far as teaching of taxonomy at undergraduate level is concerned only classical taxonomy is to be considered and that too mainly only of flowering plants. The detailed study of taxonomy of lower groups shall be set apart and reserved for postgraduate and research level.

IMPORTANCE OF TEACHING TAXONOMY

The importance of taxonomy as a branch of biological study is unquestionable. The plant kingdom is a vast assemblage of species. Without a well organised system of classification and rules of nomenclature the study of plant kingdom becomes impossible. It is true that there are other more important branches of botany like cytology, genetics, plant breeding, plant physiology etc. But none of these branches can even dream of existing without a system of nomenclature and classification. Even cytogenetics and plant breeding which are of immense practical importance depend for their working much on the hints taxonomists have thrown as far as interrelations are concerned.

Any branch of botany for its progress also depends

upon a knowledge of the available plants of the country. Even the civilization of a country much depends on this knowledge of the wealth of flora of a country. It is well known fact that the centers of Western civilization are also areas that are best known floristically. Who can say that a survey of the flora of our country will not bring to light many new species, which with such desirable characters as disease resistance, drought resistance etc. etc. may be used as parents for further breeding work.

It is gratifying to note that the Botanical Survey of India was started long ago. But it had been practically defunct for a long period. One of the reasons for this might have been lack of trained hands for the proper conduct of the survey. But since the gaining of political independence the importance of this Survey in attaining economic independence has been felt and much is being done since then. The very fact that the Ministry of Scientific Research and Cultural Affairs has got up this seminar on "The Taxonomic and floristic studies in India" and appointed Dr. Santapau, the Director of the Botanical Survey of India, as the Director of the Seminar is a recognition of the importance of this branch of botany in India which might have been one of the centres of origin of cultivated plants. If this Survey is to fulfil the aim for which it was started definitely it requires a number of trained taxonomists in the different parts of the country.

PRESENT STATUS OF TAXONOMY

Even though the importance of taxonomy is accepted by all, it is not having the place it deserves. This is more because of the supposed greater importance of the more recent biological subjects like plant physiology, cytology, genetics etc. Even in the teaching of Botany, taxonomy is considered as a dry and uninteresting subject. Only few teachers of Botany take interest in teaching taxonomy, and only very few students are eager to have taxonomy as their favourite subject. This makes one to consider taxonomy as an 'endemic' which is soon dying out. Unless proper care is taken and the system of teaching taxonomy is changed and made interesting to students, this branch of botany after a few years will get fossilised. This will surely adversely affect the progress of other biological studies.

Hence you will allow me to present to you some suggestions for making teaching of taxonomy interesting and effective.

PART II

SUGGESTIONS FOR MAKING TEACHING OF TAXONOMY EFFECTIVE AND INTERESTING

SYSTEMS OF CLASSIFICATION TO BE TAUGHT

A classification of the flowering plants is a major need in Botany. Criticism and evaluation of existing work are not difficult. But synthesising a new system is most difficult. This is so because of (1)

the tremendous complexities of the subject matter, (2) the limitations of knowledge and (3) the restricted experience possible for any one individual.

Classification of living organisms is dynamic like all science, ever approaching the truth yet never reaching it in all particulars. No system of flowering plant classification represents more than a mere stage in the accumulation of knowledge through investigations.

A list of the important systems of plant classification in the order of time is given below.

Theophrastus—287 B.C.

Ray—later half of 17th century

Linnaeus—middle of 18th century

Jussieu—later half of the 18th century

De Candolle—first half of 19th century

Endlicher—middle of 19th century

Bentham & Hooker—middle of 19th century

Eichler—later part of the 19th century

Engler and Prantl—close of 19th century

Hallier—beginning of 20th century

Bessey

Pool

Wettstein

Rendle

Pulle

Skottsberg

Hutchinson

} 20th century

There are also other more recent modifications of the earlier systems. As more and more facts come to light, it can be seen that none of these systems can claim to be truly phylogenetic.

In teaching of taxonomy at undergraduate level, which system is to be followed is the question here. For an accurate taxonomic study mere gross morphological description will not be sufficient. A correct comprehension of taxonomic study requires synthesis and evaluation of data from all possible fields including fossil record, plant geography, microscopic anatomy, embryology, developmental morphology, cytology and even serology or serum diagnosis.

But for a beginner all these are too much. The orders of Angiosperms are too numerous for immediate comprehension by the beginner. The recent systems which verge more on to experimental systems are in fact beyond the grasp of the undergraduate students. Currently larger groups are needed and these can only be partly artificial, because there is only insufficient information to make them natural. Thus for the beginner a detailed study of Bentham and Hooker's system will be quite sufficient to start with. This will serve like the ball of thread given to Theseus of the Greek legend by Anadine to find his way back through the labyrinth of facts. Moreover it may be remembered that Bentham and Hooker's system is an ancestor in some degree to every recent system.

At this point it may be admitted that in the world as a whole Engler and Prantl's system is the leading one, and that it is generally accepted as

first of the several allegedly phylogenetic systems, and that more of the major herbaria of the world are according to Engler's system. In spite of it all, a thorough study of Bentham and Hooker's classification at the outset, and then a switching on to the later classification at a later advanced stage will well explain to the students the merits of more recent classifications and the inadequacies of the earlier systems.

Even when Bentham and Hooker's classification is taught the students may be told about its defects especially in the order of arrangement of the major taxa, etc. A comparison of the place of the major taxa in these systems should be stressed. And then the students need only be told that in the light of recent findings more accurate phylogenetic systems are being attempted by various taxonomists.

MODE OF TEACHING

Two defects of the present mode of teaching of taxonomy which I wish to point out are (1) the undue importance to minute morphological details and (2) giving of more importance to minor categories than to the major taxa.

The study of morphology is important and the degree of morphological differences remain to be the principal indication of relationship in most groups and the general system of classification must be based on this. Genetical and other criteria can be claimed as superior only in some small alliances. Like genetical and other criteria minute details of morphology are required for differentiating plants only at species or variety level. Hence a beginner in taxonomy may not be burdened with all the technical terms that are to be used in describing plant parts. First, more stress is to be given to the gross differences of the major groups and then by degrees the differences between the smaller categories. A list of technical terms at the outset creates in the beginner a fear for this branch of botany. And it is with this preconceived notion that many students view taxonomy.

Another important thing to be borne in mind while teaching taxonomy to the beginners is that, as already stated at the outset, greater stress should be given only to the major taxa, *i.e.* teaching at first may be from above downwards. Say, first to be taught in detail should be the distinct features of dicots and monocots with the views regarding their evolution. Then the sub-divisions of dicots like polypetalae, gamopetalae and monochlamydeae. The requisite technical terms need be taught only as and when they are needed for bringing out the special feature, of these groups. While dealing with those groups the evolutionary significance of their distinctive features may also be stressed. Not only the gross morphology may be stressed, even anatomical, cytological and other minute details can be mentioned. This will much help them in evaluat-

ing the various views regarding the origin and interrelations. Details regarding the lower categories should be taught only after students have got a thorough grasp of the origin and interrelationships of the major taxa. This will in fact also serve to remove from the students the dread for technical terms.

Characters of the families, genera etc. should be taught only at the end.

And when once this much has been accomplished teaching of taxonomy may be from below upwards. How varieties form species, and how species can be grouped into genera and genera into families or orders and thus to higher and still higher taxa. This may even lead them on to the building up of new systems which will explain many of the problems regarding evolution and interrelationship of angiosperms.

But this type of study of taxonomy from below upwards may be reserved for postgraduate and research students.

In the light of the above suggestions my humble opinion is that the whole syllabus of morphology and taxonomy for the undergraduate course in botany should be modified on an all India basis and these standard text books be written by a committee constituted for the purpose.

Changing the model of questions for the theory and practical examinations. It is needless to say that a modification in the syllabus necessarily requires change in the model of questions. Here too the principle should be greater stress for the major taxa. Say, for example, for giving a wider outlook to the study of plants, at the time of practical examinations, students may be given twigs or flowers of any plant (*i.e.* not only of plants which come under the families included in the syllabus for detailed study) and they may be asked to refer them to any of the major taxa say division, subdivision, series, cohort or the like. As will be suggested later the field record may be submitted instead of herbarium at the undergraduate level.

EXCURSIONS

Excursions play a very important role in the teaching of botany. They help the students to study the plants in their habitat. The taxonomic studies of a flora range in extend from a compiled check list of vascular plants of a small area to a thorough taxonomic or biosynthetic analysis of the components of the vascular flora of a continent. Because of this wide scope the subject of floristic study appeals to the interest of both the amateur and the professional botanists. It is a field of interest in which the amateur botanist can take an active and contributory part. The amateur botanist, starting from the undergraduate students of botany should be encouraged to investigate such problems. For this, excursions help a lot.

But the excursions now conducted annually by

colleges for the benefit of the degree class students do not help to take full advantage of the time, money and energy spent. Now excursions extending over a period of 10 to 15 days at one stretch are conducted and that too to distant places. Such excursions are considered by students as occasions to collect as many flowering twigs as possible for their herbarium which they are to submit. That too only of plants that are included in the natural orders they are to study. They make neither a thorough study of the flora nor make a thorough collection. Much of the time is spent on, to and fro journey. It is high time that excursions are so organised that students can take the maximum benefit out of them and the country can profit.

Instead of long excursion once during the course of study, number of short trips may be arranged on occasions distributed throughout the seasons of the year. Such trips can be to near by places. This will enable the students to have a comprehensive study of the plants of the locality. And such occasions as far as undergraduate students are considered need be taken as occasions to study the plants outdoor. While making study of plants in the field, students may be made to write field records. This can be done by filling out mimeographed tables prepared specially for the purpose giving details of floral structure, ecological aspects etc. Such bonafide field study records should be submitted by students at examinations, and marks should be awarded for them. Such a study of floral and other characters will also make their study of morphology, which now is considered by many as taxing, very interesting and easy. This will create in them an interest for field study which will afterwards help to equip themselves as efficient professional taxonomists.

HERBARIUM

No doubt that herbarium forms an important aid for teaching. In addition to this the other uses are that it serves as a reference collection for checking the identity of newly collected plants. Herbaria also serve as a historical collection. The technical collection is documented by reference to individual plant specimens. It also serves as a depository for samples of the plants used in every experimental research project. It is also a body of data for research on the nature and delimitation of plants such as families, genera, species and varieties and also for mapping and analysing their distribution.

But as far as undergraduate students are concerned none of the above uses of herbarium are of very great direct importance as the first one, i.e. as teaching aid. But it may be remembered that for the beginners living plants are easier to identify than pressed specimens because the flower is not flattened. Pressing may distort the structural pattern and obscure the chief characters differentiating orders and families and as such herbarium may not be the best teaching aid (however, a student of botany

should realise the great value of a large herbarium collection). Every college, where there is teaching of botany, should have a fairly large collection of plants. Occasional reference and study of the preserved materials make them familiar with especially those plants which are not available in the locality.

But this does not mean that the students themselves must make the collection and prepare and identify the specimens. If all could be done it is well and good. It must be seriously considered that time is a limiting factor. In most of the Indian Universities degree class students are to submit their own herbarium collection at the time of the practical examination. This system of preparing and submitting herbarium is a time consuming affair with the result that it is affecting adversely their studies. If this were done as it ought to be done, that might have helped them a lot. It is felt that the preparation and identification of herbarium are not done properly. There are instances where others are collecting, drying and preparing herbarium for students and if at all, all these are done by students, in most cases the identification work is not done by students, the same being done by the herbarium keeper of the department or by the teacher handling the subject. Hence this system of submission of herbarium by undergraduate students may be stopped. Instead they may be asked to submit field records that are prepared at the time of field study.

I can say from experience that this stopping of herbarium affair for the undergraduate students has in no way adversely affected the teaching or study of taxonomy. Where this was replaced by properly conducted field study the response was encouraging. With the introduction of the three year degree course in our University, herbarium submission by degree class students was stopped. Instead more importance was given to field study and this has resulted in better response from the students.

Allow me to recall to your mind a few remarks made by H. Chaudhri in the Presidential address of the 20th annual meeting of Indian Botanical Society as far back as 1941, proposing to build up a National Herbarium for India and to effect a complete revision of the flora of India. These can be done at a nominal additional expense by proper cooperation, collaboration and coordination. We have now in the Universities and Colleges, men trained in this country and abroad who could take up the systematic study of higher plants with credit. The Botanical Survey of India may and can enlist the cooperation of the universities and the colleges, for speeding up this work, especially of those institutions where higher teaching and research in botany are undertaken. The staff and students of such institutions can undertake collection and study of plants of small areas, or definite groups of plants, and also make herbarium collection of such plants. Such collections and study may be supervised by the Botanical Survey of India. Whatever little addi-

tional expenditure may also be met by the Botanical Survey of India. (I do admit that much work has been done in this line. But most of such works were one man affair). This type of joint effort by teachers and students will enable the teachers who are in charge of higher teaching and research to give an applied bias to our subject. We have to encourage research on a utilitarian nature. The present state of affairs in our country demands it. Our country has problems for the solution of which a knowledge of botany and specially floristic study is required. Our students should study the needs of the various industrial and commercial concerns in which they could make their knowledge useful. Emphasis will have to be made on the study of drug and fibre yielding plants and other plants capable of yielding tanins, dyes and other valuable products. Our students should know our forests better, and know also the effects of afforestation and deforestation. They must know how to explore for new plants. Search for wild species is an extremely important work.

The flora of the tropical and subtropical countries have not yet been fully worked out. Let us at least strive for a complete floristic study of our vast country.

Even apart from the studies and collection of flora of small areas near about the college, year after year and in all seasons of the year, summer schools may be arranged for floristic studies. Six or seven teachers and about twenty postgraduate and research students can stay at selected hill stations for about two weeks or so making floristic study and exhaustive collections of the plants of the place. Lectures and laboratory work also may be arranged for the students during that period.

All such work at the postgraduate and research level will be possible only if proper training is given to the undergraduate students. The training imparted to them is to be such that when they go for higher studies or research they are spurred by the interest that was sown in them during the early years of study of botany. The field studies they make at the undergraduate period should be the first training ground.

BOTANICAL GARDENS

Maintenance of Botanical gardens will surely enkindle in them greater interest for floristic studies. There should be properly maintained Botanical gardens attached to every college where teaching of botany especially taxonomy is undertaken. This will serve for the cultivation of rare plants and other plants for class work. Constant visits to such gardens will be a source of inspiration for floristic studies.

Such Botanical gardens should be maintained by the public sector at the district level and on a bigger scale at the state level. They should be accessible to all interested in the study and use of

plants and their products. These properly identified, grown in such gardens, may serve plants for the further multiplication by those who are interested in their cultivation, either for medicinal, commercial or industrial purposes.

COLLECTION AND STUDY OF LOWER GROUPS

Since so much has been said about the collection and study of higher plants it does not mean that the collection and study of lower plants can be neglected. In the field of taxonomy for undergraduate students taxonomy of higher plants alone is important. But from the point of view of agriculture, fisheries, public health and many other aspects of human welfare study of lower plants also is important, especially the algae and fungi. Hence survey of the algal flora of the unexplored regions of the country should also be made wherever possible, with the cooperation of staff and students of the various colleges.

I appeal to the various university representatives and others to submit such proposals for the consideration of the Botanical Survey of India. Let us hope that the Botanical Survey of India will consider the possibilities of such lines of work.

Every attempt is to be made to make the students research minded. As stated already there are a number of problems for the solution of which a knowledge of botany is required. A mere study of the flora alone is not sufficient. What is wanted is a healthy cooperation and collaboration between the taxonomist, the geneticist, the physiologist and the like. Only this type of synthesis between the various branches of botany will produce new findings and give added vigour to solve a number of problems.

PART III

SUGGESTIONS OF VERY GENERAL NATURE

Allow me also to place before you some suggestions of very general nature which are not directly concerned with the subject of this paper, but at the same time affect the study of taxonomy. From experience it is found that the change of medium of instruction to the vernacular at secondary schools has affected the study of science subjects. Even our state which adopted vernacular as the medium of instruction in secondary schools as far back as 1940 has started sanctioning schools with English as medium of instruction. It is true that the mother tongue should be given a very important place at all levels of teaching. Such subjects as history, political science and humanities can be effectively taught in vernacular and science subjects in English even from the secondary school level.

Another suggestion is regarding the course of study between the secondary school and the undergraduate class. Many Indian Universities have introduced the one year pre-university course. I

must confess that this also has adversely affected the teaching of science subjects. In the limited period of one year they have to study practically more than what they had to study during the two years of the Intermediate course. Many feel that this has resulted in the lowering of standards in science subjects. This is, however, true in connection with the teaching of taxonomy.

Some adequate change is to be thought out and implemented to avert this situation.

While thanking you all for the patient

hearing, I appeal to the Director of the Seminar and the delegates from the universities and other institutions to give thought to the suggestions offered and convey them to the competent authorities so that suitable steps are taken as early as possible.

A special appeal to the Director of the Seminar who also happens to be the Director of the Botanical Survey of India is that all possible help and directions should be given to the various universities and other bodies who in their turn will help in building further the National Herbarium.