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SOME REFLECTIONS ON FLORISTIC DATABASES

Arturo Gómez-Pompa[1] *and Lorin I. Nevling, Jr.*[2]

Summary

After 15 years of experience with Flora of Veracruz project it seems important to make an evaluation of its challenges and accomplishments. This is important because we believe it is the oldest on-going project using computers; is the oldest floristic project initiated, directed, and financed mostly by a tropical developing country; and because it has been a success in spite of being unfinished. We have always considered the Flora of Veracruz to be an experimental flora, a place to try new ideas and techniques. Through this approach we hoped that an information and technological transfer could be possible to established or beginning floristic programs.

Introduction

Before discussing some details of the project it seems advisable to devote a few lines to the challenge and potential of floristic projects in general. Several excellent papers have been written recently discussing the problems of floras (Heywood, 1984), inventories (Prance, 1984), and databases in floristics (Bisby, 1984; Allkin and Bisby, 1984). The importance of floras has been expressed in many important publications. For example, in the National Research Council Report on Research Priorities in Tropical Biology (NRC, 1980) it is mentioned: "Local accounts of the floras of particular areas provide invaluable and original insight, illuminating the whole pattern of tropical diversity, and such studies should be encouraged." In spite of the understanding that floras today must have a high priority, as evidenced by the preceding expressions and other similar ones, the reality is very different. In the financing schemes of scientific research in most institutions and countries, floras are not a high priority; neither are herbaria, collections, nor systematic research. This decline of support is happening in spite of the efforts of many outstanding scientists to alert the world about the need to document the biological diversity of the tropics. Why is this happening? It seems that there are some fundamental mistakes that are affecting floristic research support that should be openly and seriously discussed in order to seek a positive resolution.

Time Constraint

One important constraint is the time required to produce a finished flora. We recognize that there are numerous factors that influence the time budget, such as number of workers, previous publications and knowledge of the area, complexity and size of the flora, etc. Nevertheless, time is a significant matter. Some projects need 20 or more years in order to be completed and available to users. This is a tremendous handicap for developing countries that need theoretical and applied results quickly. But what is worse, is that the information can become outdated very rapidly, especially in the tropics. Tradition has had more influence than practicality. Our experience in Flora of Veracruz tells us that it takes an average of two days for an experienced botanist to write a description of a known species (including time to select specimens and bibliography). This means that a flora of 8000 species may take 33 years to be completed by two systematists working full time 240 days per year. As most systematists do things other than writing descriptions, the time is only

[1] Department of Botany and Plant Sciences, University of California, Riverside, CA 92521, U.S.A.
[2] State Natural History Survey Division, Natural Resources Building, 607 East Peabody Drive, Champaign, IL 61820, U.S.A.

theoretical. As floristic research is a long-term commitment, the possibility of stabilized funding in this time scale is quite difficult.

Lack of Systematists

One of the reasons for the slow pace of floras is the lack of trained sytematists in general and the small subset available for floristic work. Some systematists in developed countries see floristic research as second class research or simply not addressing the real questions in biology. This is also true in developing countries where systematists are scarce or absent and where the need for floristic information is the most pressing. The successful recruitment of young persons into systematics is related to: a) availability of jobs, b) attraction as an innovative scientific field capable of yielding new discoveries, c) challenges and opportunities in the future, d) degree of modernization of approaches to problems, and e) societal recognition of its scientific contributions. Systematics is not stressing its strengths and is misjudged because of some of its weaknesses.

Need for Large Collection Resources

An additional constraint is the need for a costly infrastructure (herbarium, equipment, and library), in order to produce an acceptable floristic product. Even though loans and new collections can be of help, this is not the case for most tropical countries, where facilities are insufficient, if not absent. Collection resources in the tropics are scarce, badly funded and poorly equipped. In addition, their life span may border on being ephemeral. The floristic information badly needed by local users cannot be offered due to these shortfalls. Increasingly, this is not a problem endemic to the tropics, many smaller collections and even a few large ones in the developed world are having similar problems of meeting the increasing demand for information by an increasingly larger segment of society. In spite of these difficulties, many institutions in the developed countries are flourishing and the resources available are enormous.

The real problem in the developing countries is that the meager resources available have to be shared by a great number of disciplines. This distribution of scarce resources has damaged systematics as it is seen through the eyes of the same priorities of science in the developed countries, but without the historical baggage of knowledge and without the collection resources.

Because of these constraints, floristic research is not on the high priority list of most scientific development plans of research institutions and countries in developing countries. This is of signal importance, as the developing countries have the greatest biological diversity and the most potential for benefiting from their own biological resources which are in large part unknown. This is a major difference from the other parts of the world.

Some Additional Challenges of Floristic Research

Floristic research has some additional challenges inherent in the way it is done by many of its practitioners, that may explain some of the criticism. Many floras include insufficient and superficial descriptions. The stated reason, or even pretext, is that the flora is synoptical in nature. This cannot be considered to be an excuse for imprecise work. The time required to do a good original description is too long for the time available for floristic needs. When comprehensive larger floras, monographs or revisions are available these problems are minimal, but unfortunately the number of recent larger floras, monographs and revisions, especially of tropical taxa, are very scarce. For this reason floristic research remains a compromise and the researcher must do the best possible work within the constraints of acknowledged shortcomings. Descriptions in floras are extremely repetitive for the same reasons. One description is a concentrated and hopefully enriched version of another description. Even the mistakes are repetitive!

Today a few floras do in-depth original research. Some outstanding examples are: the

Generic Flora of Southeastern United States, *Flora Neotropica,* and *Flora Malesiana.* But they have to pay their time dues, and their completion may very well be 50 or more years. It is fair to say that some of these floras have better descriptions, documentation, and in-depth discussion than some monographs and revisions.

Another consequent risk is the problem of interrupted floras. Very often a floristic project is related to leadership of only one person who is the promoter. If something happens to him or her, the project ends unfinished. It seems that institutional or multi-institutional floristic projects are the only viable long-term solution for this problem, but this is difficult in any country.

The Urgent Need for Floristic Research in the Tropics

In contrast with all these constraints, the need for floristic research in the tropics is greater now than at any other time in modern history. If there is one single thing that we can identify as the major universal biological concern of humankind today, it is the threatened tropical biota. We are living in a turning point in history in the extermination of thousands of species of plants, animals and microorganisms in the tropics. In the Conference on the Resources of the Biosphere (UNESCO, 1968) in which the Man and the Biosphere Program of UNESCO was created, the following paragraph was included:

"*Recognizing* that only a very small number of the numerous plant and animal species are directly utilized by man,
Taking into account the accelerating rate of species extinction,
Suggests, that special efforts must be taken urgently to preserve the rich genetic resources that have evolved over millions of years and are now irretrievably lost as a result of human actions."

This issue was also a high priority in the initiation of the United Nations Environmental Program. Many private non-governmental organizations such as the International Union for the Conservation of Nature, World Wildlife Fund, the World Resources Institute and many others devote funds and act to protect the biological diversity of our biosphere. There is a dramatic need to know what we have and what is most in danger of extinction. The great incongruity is that we do not know the flora of the tropics. New species are turning up every day from scattered expeditions to the tropics. Only from Mexico in the last few years a new wild corn was found in Jalisco (Iltis et al., 1979), and a new genus of woody bamboos was described from Veracruz (Soderstrom, 1981). These are samples of the very many species that have been described from these two of the "best" known states of Mexico.

But the need for floristic research does not end in the conservation arena but only begins. The reason for conservation is the need to keep future biological options available for the next generation. These options may be new foods, new raw materials for industry, new medicines, new species or varieties of wild relatives of the cultivated crops as banks of genes, etc. These options obviously are of great importance, but in order that they will be used we should know some basic facts. Where do they grow? How can we identify them? What local uses do they have? Are they abundant? Are they threatened? Who has monographed them? These questions are a few of the most important ones that floristic research attempts to address. The need for an identification may come from a medical doctor treating a case of plant poisoning, a chemist doing analyses of presumed medicinal plants, a cattle rancher for identifying a possible poisonous plant, a forester needing to know the species of trees in a forest he is going to cut, a farmer of the weeds he wants to be rid of, or a flower lover who wants to learn more about a beautiful flower. All of these are users of floristic research. Floras should provide the bridge between the hard-core systematic research and the general public. But, do they?

Flora Research and Conservation

Floristic scientists frequently are the first witnesses of projects threatening to important biotic areas of the region under study and may be among the best people to advise on regions to be protected and conserved. Floristicians and of course, herbaria, should be the most knowledgeable people and institutions on conservation matters. But the reality is that they are not. Most of the conservation "movement" uses floristic research and collections as sources of information but not as principal actors in the conservation play. We are so busy in our nomenclatural problems, descriptions, and methods that we have let pass a unique opportunity to be important in the world. Of course this is not totally true as there are notable exceptions. We do not know the floras of most tropical national parks or reserves. Millions of dollars are spent in protection of areas for their biological richness, and we do not know what they contain and little effort is made by the systematic community to find out. Two of the best known tropical biological stations in the American tropics (La Selva in Costa Rica and the Los Tuxtlas Station in Veracruz) are lacking good inventories. Two remarkable examples to the contrary are the Flora of Barro Colorado (Croat, 1979) and Rio Palenque (Dodson and Gentry, 1978). A change in priorities may be in order and the systematic community should pay more attention to a world plant inventory of the protected areas (Gómez-Pompa, 1985).

The Flora of Veracruz

During the development of the Flora of Veracruz (FV) we were aware of some of these problems, and perhaps our positive and negative experiences can help others to understand more clearly some of the issues. For many of the reasons mentioned above, the Flora of Veracruz project started from a different perspective than many other floras. From the beginning the emphasis was placed on building floristic and environmental databases, with the objective of developing an information system. The system was designed to provide service as soon as possible to the potential users and left as a second priority (in time) the publication of the family descriptions. This strategy was the correct one, as it can be demonstrated through the great number of users of FV databases through the years.

Details on the history and evolution of the computerization of the Flora of Veracruz have been published (Gómez-Pompa, 1972; Gómez-Pompa and Nevling, 1973; Gómez-Pompa et al., 1975; Gómez-Pompa et al., 1984). Today the FV uses computers as a routine procedure for most needs. Continuous revisions and updates are the most important routines. Unfortunately we have had to accept that the database approach of Flora of Veracruz was subject to criticism from the beginning, in spite of the fact that we have been providing information to a variety of users. This criticism was probably because we did not follow the traditional way of doing floras, and we were not publishing keys and family descriptions. In spite of the fact that we have been providing information to a variety of users from the beginning! Our original plan was to publish annotated checklists with keys, maps, and illustrations. But funding required family treatments, and we began them (Gómez-Pompa, 1978–1986). The first published family with one genus and one species (Hamamelidaceae, Sosa, 1978) is outdated and has doubled its taxa (two genera and two species).

Information Challenges

The main problem we have had with the initial curatorial database (herbarium label information), has been the quality of the information, which is not totally reliable. This is a general problem for all collections. There are additional mistakes made by the people capturing the information. There are ways to solve this problem, but they increase the cost of the effort. Two approaches have been followed to review the information of the database through the years. One is to update the data during the process of the production of the family fascicles. The second one has been to enter directly corrections to the database by technical staff of the FV. These corrections are made mainly in the spelling of scientific

names in the central database. Very few persons are authorized to make these corrections as they are based on names and synonyms from recent revisions, monographs, or floras. Even with this technique there are some important contributions that are missed. But the difference is, that we can update the database as soon as we find gaps or errors.

Coordination

We have faced many difficulties in FV due to coordination problems. A central database that is constantly updating its data and its software is very useful, but it is very easy to outgrow any one person's ability to keep up. A very important conclusion from our experience is the need to have complete institutional support for a project of this type. It is an unending process that requires proactive coordination and collaboration, but the results are far greater than a traditional scheme.

In our efforts to keep up with label data and newly acquired specimens in Xalapa, and other collaborating institutions, we have asked the curators of herbaria in Mexico to help. In FV we have accessed in our database all the Veracruz collections from Xalapa (XAL), from the National Herbarium at the National University of Mexico (MEXU), and from the Polytechnic Institute (ENCB). The database is large, and updating it has not been easy. New accessions come to all collaborating herbaria and changes in identification also are occurring. In order to keep our data updated we have asked the curators to segregate all new accessions and changes. This sounds easy but in practice is not. If these problems were significant in Mexican herbaria, to do it in other herbaria surveyed, A, GH, F, and K, was impossible. Our only consolation was that new collections from Veracruz were done by our staff or with our knowledge. Keeping current the changes in the identification of specimens in those herbaria was an impossible dream.

Scarcity of Systematists in Mexico

The most important problem that we faced at the beginning of FV was the lack of professionally trained systematists in Mexico. Therefore, the first efforts were directed towards attracting bright young Mexican biologists into the project. The initial effort was in stimulating new plant collections and to develop good and reliable information. The main approach was to stimulate local ecological studies that produced very badly needed information and also herbarium specimens. This was successful and several outstanding Mexican systematists were stimulated and initially trained by these initial efforts of the Flora of Veracruz. One of the most significant contributions has been the studies on rainforest regeneration based on the Veracruz research (Gómez-Pompa and Amo, 1985). Unfortunately, some of the collections were not as rich as we expected, even though the data for which they served as vouchers was of high quality.

There are many kinds of problems involved in the use, maintenance and updating of a database of this sort. The size of the files requires a huge memory, only available in large computers. This was a limiting factor as this sort of capability was available only on a time-shared basis from large institutions. In the priority schedule for time and advice, we were at the end of the line. The solution came six years ago when a computer was bought by INIREB (a VAX-11-780), assigned to FV, and given the highest priority until 1984. Another important problem that we experienced through the years was the availability of the best software programs to run the data of FV. Commercial programs at the beginning of FV in the 60s were too expensive and in-house programs were written (Gómez-Pompa et al., 1975). For the daily user of FV databases this was not a problem as instructions on changes were available, but for occasional users it was a problem as some of the programs were not "user friendly." When the new computer became available in 1980, a large and painful transfer of programs and data was undertaken. The new computer had data management programs available that were used to write "friendly" programs for the management of FV database (Gómez-Pompa et al., 1984). They are mainly menu driven (Fig. 1).

Fig. 1. Main menu for the consultation of INIREB's floristic data bases.

We don't have the "final" program; new additions and changes are always in order. New commercial programs to manage files like FV are now available at significantly lower prices and computers themselves have increasing memory size coupled with lower cost. A new computer, a Micro VAX-station II, totally compatible with the VAX at INIREB, is now available for the Flora of Veracruz at Gómez-Pompa's laboratory at Riverside. One thing that needs to be said is that through this time the data that were captured have been transferred without a problem from punched card, to diskettes, to tapes, to hard disks.

Some Accomplishments

One outstanding accomplishment by this approach was that not only were systematists stimulated and trained but also many outstanding ecologists. The facilitation of botanical identification and the availability of information through the databases of the Flora were of fundamental importance for many projects (Amo, 1979a) in this stage. It is not an accident that the most important ecological activities and studies, basic and applied, of Mexican botanists and ecologists have been done in Veracruz in the last 15 years. The knowledge of the Flora of Veracruz and especially the field activity of its collaborators, has been one of its characteristics through the years. It has given fresh information on deforestation in critical areas. This has been the major reason for the public controversy surrounding the Uxpanapa colonization project (Gómez-Pompa, 1979), in an area which is the type locality of *Olmeca* (Soderstrom, 1981) and many other new taxa.

The activities of Flora of Veracruz were the fundamental basis for the creation, by the federal government of Mexico, of the first National Research Institute for the study of the flora and fauna of Mexico: the National Research Institute of Biotic Resources (Gómez-Pompa and Giddings, 1986). This was a major step for the Flora of Veracruz. The institutionalization of the project was then a reality and for the first time in its history had a computer devoted mainly to the different projects related to the environment and plant

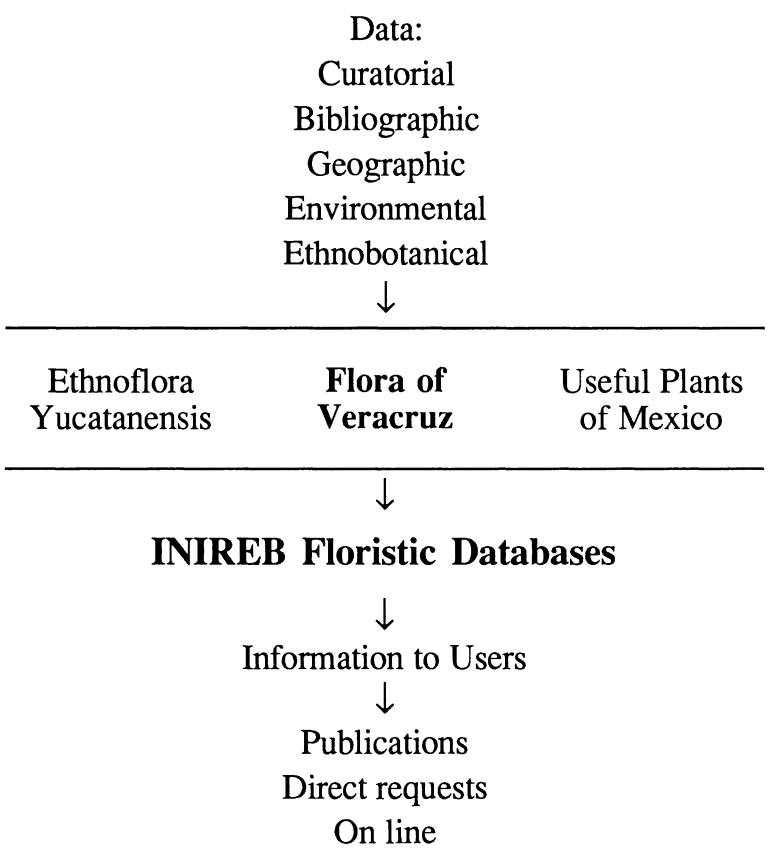

Fig. 2. Organization of floristic databases of INIREB.

resources of the state of Veracruz! It is impossible to identify all the activities and projects that were stimulated or developed by the influence of the databases of the Flora of Veracruz, in Veracruz and elsewhere (Fig. 2).

The Curatorial Database

The first effort of the Flora of Veracruz was in the capture of label information on specimens collected in Veracruz. This effort led us into a giant effort to review the principal Mexican herbaria (XAL, MEXU, IPN) and three of the larger U.S. Herbaria (A, F, GH) and a good part of Kew and selected collections at the British Museum of Great Britain. This curatorial database (Fig. 3) which is now more than 90 megabytes of size (more than 80,000 entries) is the most important source of uncollated data on Veracruz plants and is consulted constantly by botanists at INIREB, very frequently by botanists in Veracruz, and much less frequently by botanists from other institutions. This database serves as first-hand information available to answer questions related to the plant resources of Veracruz, either by the public or by researchers. We have been able to provide information to systematists, agronomists, chemists (Amo, 1979b), physicians, farmers, and students, on an infinite number of queries, such as toxic plants in some areas, distribution of species, precise localities for certain species, uses of species, local names, etc. The next step of the FV is to transfer and divide the large files into smaller files that can be utilized by a PC with hard disk.

Another new development of FV is the use of laser disk and CDROM technology to build a visual database of specimens, slides, drawings, and maps related to Veracruz plants

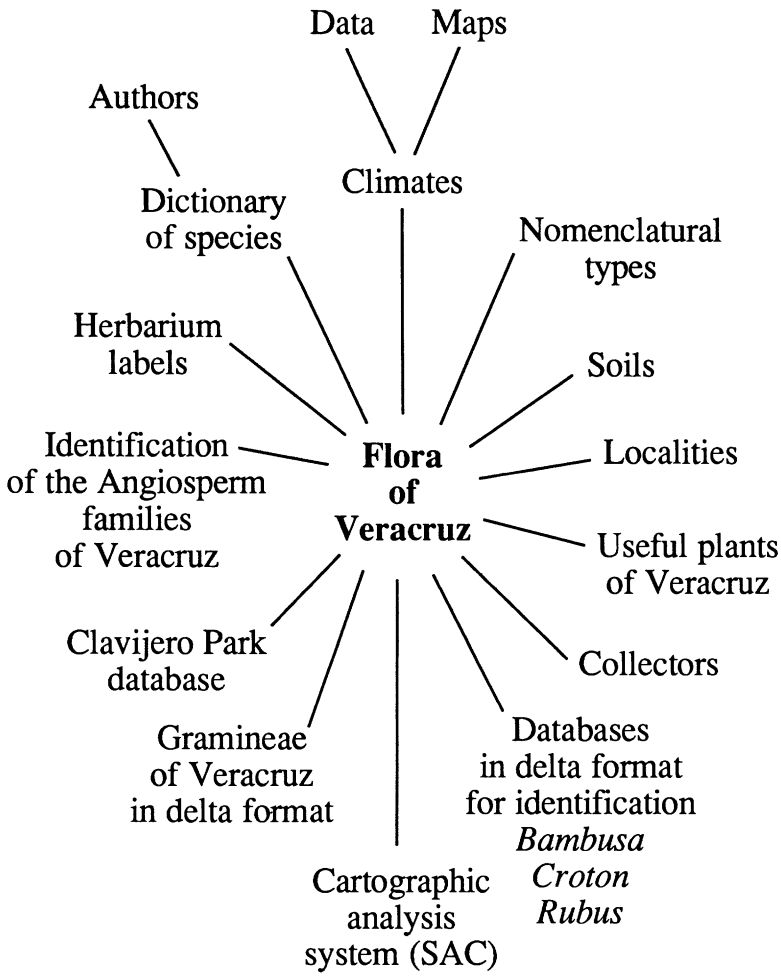

Fig. 3. Flora of Veracruz databases.

and environments. This new database could be very helpful for our users and especially for computer aided identification.

Checklists of FV

Checklists of the FV have been available since 1969 (Gómez-Pompa and Nevling, 1969–1972) for the collaborators of FV. At the beginning we kept track of each iteration but later we dropped that attempt as every week a new version was produced for a user. As the checklists were only printouts of whatever was captured from labels, its use was only of interest to systematists and not to the general public. However the demand for tailored checklists has increased recently and for that reason a decision was made to publish a revised and annotated checklist of the FV for 1988. This checklist will be permanently updated in order to publish editions every time we feel it is worth it.

One problem we have found is the reduced contribution for the updating of our database by most of our local collaborators in the descriptions of families for FV. The reasons are the unavailability of collections from the original sources of our database, especially the United States and England. This means that many specimens are not seen and proper identification is not annotated. An effort is planned in the future to encourage the review

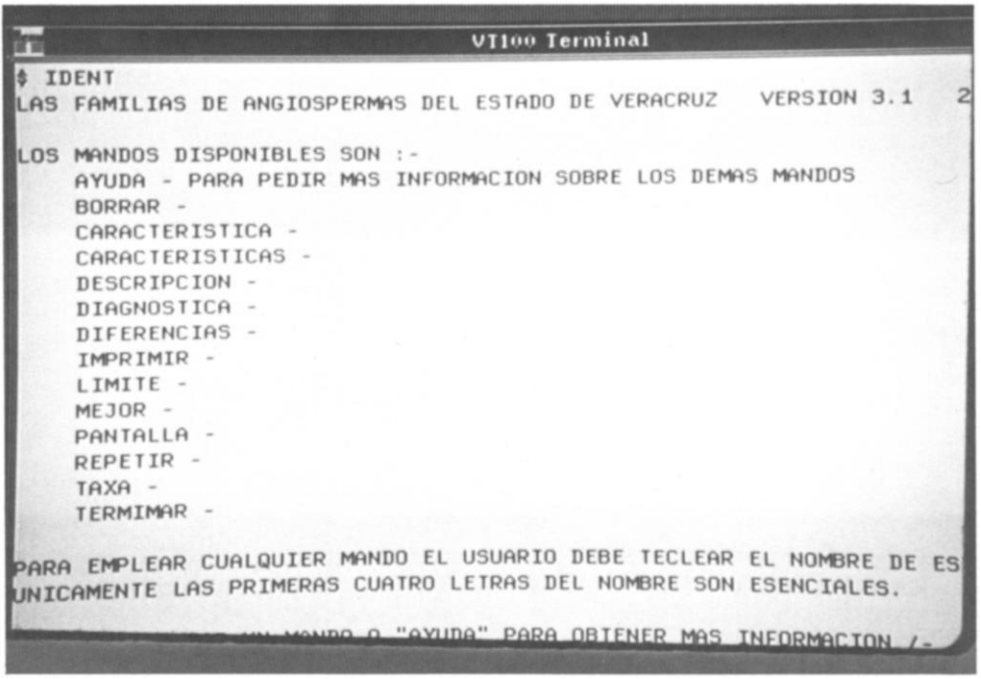

Fig. 4. Main menu for on-line identification of families of flowering plants of Veracruz.

of as many specimens (or photos) as possible from the main herbaria included in our database. The problem is not surprisingly one of funds.

Computer Aided Identification

One of the principal objectives of any flora is to provide keys and other information that can help in the identification of specimens. The FV includes keys in the treatment of the families. Unfortunately, there are many occasions in which the key is useless for the identification of an incomplete specimen. There are many family treatment keys that remain to be written. Visual comparison can help by matching the specimen with known taxa. But this may be impossible as most of the species are not illustrated. For these reasons it was decided to explore the possibility of using the computer to help in the identification process (Allkin, 1981; Pankhurst, 1983; Moreno et al., 1984). This project was done with the collaboration of Richard Pankhurst of the British Museum and Robert Allkin at INIREB. A program was written for the identification of the plant families of Veracruz and for a few selected taxa. This has been a very useful project that has helped explore new techniques and train young staff of FV to help in the initial identification of newly collected specimens. The program for on-line identification available for FV is also menu driven (Fig. 4). After a few years of experimenting with different approaches, we have started a long-term effort to create botanical databases for all families of Veracruz for identification purposes. The most important contribution has been the publication of a standard glossary for descriptions (Moreno, 1984) complemented with a guide for the contributors (Gómez-Pompa et al., 1979).

The possibility of generating descriptions of taxa has been explored, with the advice of Richard Pankhurst, and even though the project is feasible, its usefulness is not clear. As we foresee its possible future usefulness, we will digitize future taxa descriptions using the DELTA format of Dallwitz (1980). The advantage of using this format is its widespread use and its compatibility for use in the automatic identification programs of Pankhurst.

Palynological Flora of Veracruz

In 1979 a project for the study of the pollen flora of Veracruz began under the direction of Beatriz Ludlow (Martinez-Hernández and Ludlow, 1978; Ludlow, 1978–1985). Each published family is studied from the palynological point of view and a description is published as a contribution to FV in the journal *Biotica*. This pollen flora has stimulated paleoecological research and is standard information for anyone interested in tropical pollen of Mesoamerica.

Environmental and Geographic Databases of FV

As one of the original purposes of FV was to undertake ecological studies in the state, it was decided to computerize some geographic data. The geographic databases of FV include: a) computerized data of all the meteorological stations of Veracruz, b) digitized climatic and soil maps, c) geographical gazetteer of Veracruz, that includes altitude and longitude for each locality, and d) computerized mapping of FV taxa.

Climatic Profiles of Veracruz

The information on the climates of Veracruz combined with the curatorial database on the geographic distribution of taxa has permitted the development of a project for producing climatic descriptions for each taxon of the FV (Soto et al., 1985). This project has many practical applications in agriculture planning, as it is possible to predict climates in which a species can be grown based on the known climates in which it currently grows. This information has promoted several independent projects on land use planning for Veracruz that enrich the geographic databases of FV.

Ethnoflora Yucatanensis

One of the most outstanding applications of the approach and methodology of FV has been the Ethnoflora Yucatanensis (Sosa et al., 1985). This project includes curatorial, geographic databases and a new one, an ethnobotanical database. The importance of this project is in the extraordinary amount of traditional knowledge that the present day Maya have retained. In this project, the training of botanists also has high priority. The only difference is the inclusion in the Yucatan of young bright Maya farmers who, with good knowledge of the plants, have been retained as research associates. These trained collaborators gather information from other Maya farmers.

Useful Flora of Mexico Database

In the Flora of Veracruz project and in the Ethnoflora Yucatanensis project we have experienced great demand for information unavailable in our databases. The uses of a plant are captured only if the data are included on the herbarium label. Because of this, some years ago we started an effort to build a database on useful plants of Mexico based on literature surveys (Avendaño, 1981). The project included the data from the curatorial database in addition to the bibliographic one. The plan was to capture from more than 100 publications all the information on the uses of plants. Most of this uncollated information is available for consultation and is in the process of revision.

The Future

It is impossible to predict the future of any floristic project. It will depend on the funds available and people committed to it. We hope that the basic project of FV will continue as a multi-institutional and multi-national research project on floristic databases. The main headquarters in Mexico will remain at INIREB as long as the institution can continue its support. In the U.S.A., headquarters will based at the University of California (Riverside and Berkeley) with strong links with a consortium of institutions from the U.S. (Field Museum of Natural History, New York Botanical Garden, University of Texas, Rice University) and England (University of Southampton) to contribute in the many aspects

of research of the project. In no sense is it to be conceived that the FV is a closed activity, all that are interested in a cooperative experience are urged to contact the Flora leadership. The new relationship with the University of California (Riverside and Berkeley), will enhance the training process for new botanists interested in experimenting with new approaches in floristics and systematics, and also will stimulate research in the exciting and fast evolving field of computer applications in data management.

One of our aims is to exchange and distribute, in a computer readable form, different packages of programs and information to users and libraries, following the model of Duncan in his distribution of their Mekka program (Duncan and Meacham, 1986). We will continue with the publication of family fascicles and other contributions to the Flora. But most importantly, we will continue our exploration for new approaches in floristic research, and will continue our student training activities in floristic and ecological research in Veracruz.

Computers offer enormous possibilities to enhance floristic research. The future is brighter than ever and even though great advances and improvements in hardware and software can be predicted, the work done to capture information in computer readable form today will be useful tomorrow. A great effort to exchange information on formats for the fast transferring of files is greatly recommended.

These random thoughts on floras in general and the Flora of Veracruz in particular are directed to those who hold the position to influence the outcome of the race to know and to protect the tropical flora (Wilson, 1985).

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