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MANAGING ETHNOPHARMACOLOGICAL DATA: HERBARIA, RELATIONAL DATABASES, LITERATURE

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1.0 Introduction

The management of ethnopharmacological data is a complex issue due to the interdisciplinary nature of the discipline. Research questions and methods vary widely depending on the training and background of the researcher(s). This can lead to difficulties in standardizing data and engaging in comparative approaches. The field of ethnopharmacology involves people's use of plants, fungi, animals, microorganisms and minerals, in the context of traditional medical systems. It is concerned with identifying the biological and pharmacological effects of these materia medica, and communicating that information based on the principles established through international conventions. Early humans confronted with illness and disease, experimented and discovered a wealth of useful therapeutic agents in both the animal and plant kingdoms. The empirical knowledge of these medicinal substances and their toxic potential was passed on by oral tradition and sometimes recorded in herbals and other texts on materia medica.

Today, at least 121 plant derived pharmaceutical drugs including belladona alkaloids (e.g. atropine, hyoscyamine, and scopolamine), digoxin, cocaine, the opiates (codeine and morphine), tubocurarine, digoxin, reserpine, taxol, tubocurarine, quinine and reserpine were discovered and commercialized through the study of traditional remedies. Natural products investigation based on ethnopharmacological leads continues, although the resurgence of interest in ethno-bioprospecting in the late 1980's and 1990's has declined lately, mainly due to the lack of new pharmaceuticals being creatd through such approaches. Of perhaps more current siginificance is the use of ethnopharmacological leads as a backbone in combinatorial chemistry to create new pharmaceuticals. Chemists continue to use plant-derived compounds (e.g., emetine, morphine, taxol, physostigmine, quinidine) as prototypes in their attempts to develop more effective and less toxic medicines.

In recent years, the preservation of local knowledge, the promotion of indigenous medical systems in primary health care, and the conservation of bio-cultural diversity have become vital issues to all scientists working at the interface of social and natural sciences but especially to ethnopharmacologists. Recognizing the sovereign rights of States over their natural resources, ethnopharmacologists are particularly concerned with local people's traditional rights to further utilization and development of their traditional knowledge and autochthonous resources. In view of that, today's ethnopharmacological research embraces the multidisciplinary effort in the documentation of indigenous medical knowledge and scientific study of indigenous medicines in order to contribute in the long-term to improved health care in the communities of study as well as, to search for pharmacologically unique principles from existing indigenous remedies.

Ethnopharmacological data management is similar to that of the broader field of ethnobiology, in that researchers rely heavily on voucher specimens of organisms and associated data collected with the voucher in order as the primary unit of data. However, ethnopharmacological data management has the added complexity of data related to medical practices and, sometimes, chemical analyses of the voucher specimens. Recent advances in database technology hold promise for the organization and analyses of complex data.

2.0 Historical Trends

Scientific collections and data in ethnopharmacology date back many centuries. As early as the 13th century humans started to systematically collect voucher specimens of plants and store them in collections which evolved into herbaria. The development of herbaria coincided with the development of the printing press and subsequently, libraries. In fact, herbaria had much in common with early libraries because plants were dried and pressed and then glued into blank pages of books. Some of the earliest herbaria are found at at the Naturkundemuseum in Kassel, Germany (1569) and at the universities of Bologna (1570), Basel (1588), and Oxford (1621).

Later herbaria starting around the 18th century began using specimens mounted on loose sheets of paper. This allowed for the shuffling of collections as classifications schemes matured and changed. The publication of *Species Plantarum* by Carl Linnaeus in 1753 revolutionized classification by providing a global system for the classification of organisms. Through the development of a binomial nomenclature, Linnaeus standardized the way herbaria cataloged collections.

Because herbarium collections are spread across many institutions and geographic regions they have been historically difficult to utilize and compare. Retrieving ethnopharmacological research data has always been challenging because much of this information is published in disciplinary journals from diverse fields (e.g. botany, biology, anthropology, conservation biology) or in "gray literature" (eg. unpublished works, government documents and technical reports) that are not widely accessible. The diffuse distribution and variable quality of this data limit the ability of scientists to easily obtain access to either legacy data or current published ethnobotanical research. Large poorly maintained databases, some which are proprietary also exist in institutions but are not accessible to the wider scientific community.

A decade or two ago, a researcher interested in learning about the medical use of a particular plant species may have had to scan index cards, field notes and personal journals in order to find what had been collected, where and for what use. To learn what was contained in herbaria and museum collections a researcher had to physically visit them. This situation, however, is rapidly changing as a result of what has been described as the quiet revolution of information technology and bioinformatics. Today, an increasing amount of data from ethnopharmacological research is being stored and curated electronically.

3.0 Present Trends

3.1 Ethnopharmacological Databases

Probably, the largest collection of ethnopharmacological data is held by the Program for Collaborative Research in the Pharmaceutical Sciences College of Pharmacy, University of Illinois at Chicago NAPRALERT (Natural Products Alert) database. NAPRALERT, an acronym for NAtural PRoducts ALERT, is the largest relational database of world literature describing the ethnomedical or traditional uses, chemistry, and pharmacology of plant, microbial and animal (primarily marine) extracts. While at its core the database is concerned with coverage of natural products, whether used by humans or not, a substantial portion of the database is within the realm of ethnopharmacology. NAPRALERT is a relational database that is fee-based, except for researchers from Third World Countries whose access is free of charge. which contains bibliographic and factual data on natural products, including information on the pharmacology, biological activity, taxonomic distribution, ethno-medicine and chemistry of plant, microbial, and animal (including marine) extracts (Figure 1). In addition, the file contains data on the chemistry and pharmacology of secondary metabolites that are derived from natural sources and that have known structure. It is a "source" type of database as opposed to more the common type known as a "bibliographic resource" which only contain citation information, NAPRALERT currently contains the extracted information from over 170,000 scientific research articles. The NAPRALERT File contains records from 1650 to the present. Approximately 80% of the file is from systematic survey of the literature from 1975 to the present. The remaining records were obtained by selective retrospective indexing dating back to 1650. Over 151,000 plant, animal, marine and microbial organisms are covered with over 1.5 million entries on their biological activities. The database contains four main record sets for each entry: demographic (similar to that of a standard bibliographic file but with select additional information added); organism (full taxonomic description, part of organism studied); compound (when available, information is provided on the chemical composition and percentages of the organism); and pharmacology (biological activities and effects). The database is kept current by a team of scientists who systematically review relevant literature and extract pertinent information into the database. Over 600 articles are added each month from over 700 journals. Comprehensive abstracting services are also utilized and scanned for relevant articles. The secondary literature indices that are incorporated into NAPRALERT include Index Catalog of the Surgeon General (1880-1961), Index Medicus (1897-1927; 1960 to present), Chemical Abstracts (1907 to present), Quaterly Cumulative Index Medicus (1916-1956), Biological Abstracts (1926 to present), Current List of Medical Literature (1941-1959), United States Armed Forces Medical Journal (1950-1960), National Library of Medicine Current Catalog (1966 to present), and Current Contents-Life Sciences (1967 to present). Over particular utility in the database are the numerous search functions available. Some search fields available that would be of particular interest in ethnopharmacological research are: 1) verify, where a search is conducted to determine if a Latin binomial is valid within the database or if a synonym is required; 2) common-this feature provides all common (ethnobiological) names for a particular Latin binomial of an organism; 3) ethno-which provides information on traditional uses of a particular genus or species 4) exper- or biol-information on all experimental biological testing on a particular extract or compound from an organism; 5) cmpd- a list of all compounds in a genus or species 6) occ-a list of all organisms from which a compound has been identified.

Figure 1. NAPRALERT Search Example

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DISPLAY ALL

AN   92:17094  NAPRALERT
DN   H06008
TI   (+)-ALPHA-VINIFERIN, AN ANTI-INFLAMMATORY COMPOUND FROM CARAGANA
     CHAMLAGU ROOT
AU   KITANAKA S; IKEZAWA T; YASUKAWA K; YAMANOUCHI S; TAKIDO M; SUNG H K;
     KIM I H
CS   COLL PHARM, NIHON UNIV, CHIBA 274 JAPAN
SO   CHEM PHARM BULL (1990) 38 (2) p. 432-435.
DT   (Research paper)
LA   ENGLISH
CHC  1424
ORGN Class: DICOT  Family: LEGUMINOSAE  Genus: CARAGANA  Species:
      CHAMLAGU [LAMK.]
      Organism part: DRIED ROOT
      Geographic area (GT): SOUTH KOREA; EAS
      TYPE OF STUDY (STY): IN VIVO.  Classification (CC):
          ANTIINFLAMMATORY ACTIVITY
          Extract type: ETHER EXT
          Dosage Information: INTRAGASTRIC; MOUSE; DOSE: 300.0 MG per KG
          Qualitative results: ACTIVE
          Comment(s): VS.CARRAGEENIN-INDUCED PEDAL EDEMA..
      TYPE OF STUDY (STY): FOLKLORE.  Classification (CC): ANALGESIC
          ACTIVITY
          Extract type: HOT H2O EXT
          Dosage Information: ORAL; HUMAN ADULT
          Comment(s): USED AS AN ANTI-NEURALGIC..
      TYPE OF STUDY (STY): FOLKLORE.  Classification (CC):
          ANTIINFLAMMATORY ACTIVITY
          Extract type: HOT H2O EXT
          Dosage Information: ORAL; HUMAN ADULT
          Comment(s): USED AS AN ANTI-RHEUMATIC AND AN ANTI-ARTHRITIC..
      TYPE OF STUDY (STY): ISOLATION.
          COMPOUND. Chemical name (CN): VINIFERIN,ALPHA: (+)
               CAS Registry Number (RN): 62218-13-7
               Class identifier (CI): OXYGEN HETEROCYCLE
               Yield: 00.00039%
      TYPE OF STUDY (STY): IN VIVO.  Classification (CC):
          ANTIINFLAMMATORY ACTIVITY
          Dosage Information: INTRAGASTRIC; MOUSE; DOSE: 10.0 MG per KG
          Qualitative results: ACTIVE
          Comment(s): VS.CARRAGEENIN-INDUCED PEDAL EDEMA..
          COMPOUND. Chemical name (CN): VINIFERIN,ALPHA: (+)
               CAS Registry Number (RN): 62218-13-7
               Class identifier (CI): OXYGEN HETEROCYCLE
      TYPE OF STUDY (STY): ISOLATION.
          COMPOUND. Chemical name (CN): GLYCEROL-ALPHA-LIGNOCERATE
               Class identifier (CI): LIPID
          COMPOUND. Chemical name (CN): GLYCEROL-ALPHA-CEROTATE
               Class identifier (CI): LIPID
          COMPOUND. Chemical name (CN): GLYCEROL-ALPHA-MONTANATE
               Class identifier (CI): LIPID
```

The Internet provides a range of other databases based on either primary research or secondary research such as literature searches. Most of these tend to not be global in extent like NAPRALERT but tend to focus on particular socio-linguistic groups or regions. Of particular note is the database developed by Daniel Moerman at the University of Michigan-Dearborn on Native American Ethnobotany (http://herb.umd.umich.edu). The database contains information on plant derived foods, drugs, dyes and fibers of Native American Peoples. As a medical anthropologist, Moerman has devoted a significant portion of the database to ethnopharmacological data. Moerman has spent over 25 years in developing the database through the systematic exploration of scientific literature, ethnographic accounts and historical documents. The result is virtually a census of plant use by Native Americans. The database contains 44,691 items which represents uses by 291 Native American groups of 4,029 species from 243 different plant families of which 24,945 are ethnopharmacological entries representing 2582 species. In addition, the database is linked to the United States Department of Agriculture PLANTS database (http://plants.usda.gov/). This allows for the cross referencing of botanical information for each plant along with pictures, range maps and endangerment status.

3.2 New Models for Ethnopharmacological Databases

During the last decade, great efforts have been made to archive ethnomedicinal knowledge and to utilize this data in the search for novel plant-derived pharmaceuticals. Two different approaches, random and targeted, were utilized and the targeted selection programs were generally of three types.

In phylogenetic surveys, the close relatives of plants known to produce useful compounds are collected. In ecological surveys, plants that live in particular habitats or have certain characteristics are selected. And in ethnobotanical investigations, plants used by indigenous peoples in traditional medicine are collected for analysis. Although ethnobotanical approaches to drug discovery are of significant historical importance, many pharmaceutical companies now believe that new approaches, incorporating molecular biology and combinatorial chemistry, supersede traditional knowledge as a potential source of new pharmaceuticals. As a result of this often deeply rooted divide, the concept of developing comparative data models has not been explored. Consequently, random and targeted pharmacological data have remained isolated.

Currently, no data model incorporates all three primary methods of targeted selection including phylogenetic, ecological, and ethnobotanical sampling approaches. The model proposed here, however, does provide for such a comparative mechanism. By using object descriptions of plant species, genera, or family and including information about the plant's chemical properties, that plant's ecology, chemical description, and relationships can be handled. Comparative associations among related chemical structures can be represented including multimedia three-dimensional virtual models. It is clear that there is considerable collaborative potential in developing such a comparative model since not more than 1% of the species of flowering plants have been exhaustively studied to determine their chemical composition and medical potential. Data derived from the combination of all three of these targeted sampling techniques might approach an analogy to human bioassay data, and provide ever-increasing unified evidence of efficacy or acute toxicity. In the data model, these four disciplines and their related taxonomies are represented using superclasses and subclasses. For example, the Instance is a particular voucher specimen of a medicinal plant native to Brazil, *Pilocarpus jaborandi* Holmes. The instance has a particular combination of parameters (properties), which could be automatically classified within the taxonomy of the related disciplines. For example, the specimens correct habitat position below "Moist Rain Forest" is shown in the left Ecology section. Its correct taxonomic position in the order

Sapindales, family Rutaceae is shown in the upper Plant Systematics section. Its use as a medicinal is identified to the right in the Economic Botany section. Finally, its use as a treatment in Ear, Eye, Nose and Throat therapeutic category more specifically for treating glaucoma is shown in the lower Pharmacology section. This example demonstrates the collaborative approach and ability of the proposed database model to demonstrate a comparative analysis of various classification systems within the database. It should be noted that the database is designed to be extensible meaning the database supports the addition of other taxonomies such as linguistics or specific indigenous taxonomic classification systems.

3.3 Managing Field Data and Workflow

Only a decade ago, a researcher's primary tools used to conduct field research were a pencil and notebook. However, with the emergence of the digital information age, today a plethora of digital tools and software are available and being used in the ethnobiologists' toolkit. Notebook computers, Global Positing System (GPS) units, digital cameras, digital video and handheld personal data assistants (PDAs), CD-ROM/DVD technology are rapidly becoming ubiquitous field research tools, especially with students and increasingly among community collaborators themselves. With this technology also comes an accelerating quantity of accumulated digital research data. Researchers are finding themselves unfamiliar with the risks and long-term consequences of utilizing digital tools. Some researchers have even suggested that field research time is restricted since they are increasingly spending time manipulating, transferring and backing-up research data so that it does not jeopardize the integrity or security of their research.

Digital cameras and the images they produce are increasingly being utilized in field research to produce rapid, low-cost field guides useful for reviewing field data with collaborators and repatriating traditional knowledge to participants for ethnobiological or community information systems. However, no standard manual for best data management practice or solutions to the long term storage and curation of digital data exists. Therefore, individual researchers are independently grappling with the increasing amount of digital data and long-term curation.

Metadata is a powerful tool that has not been widely adopted by researchers. The lack of an Ethnobiological Core element – metadata for digital data has been recognized. A new idea to require images to meet the minimum core being a requirement for publication in scientific journals like the Journal of Ethnopharmacology has been proposed. Such a requirement would also offer the opportunity for a shared data resource or repository of data relating to published research. The following is a proposed core based on the Dublin Core Initiative (Table 1). - http://dublincore.org/about/ or http://dublincore.org/documents/1999/07/02/dces/

Table 1. Proposed Meta-data Standard for Ethnobiological Digital photographs.

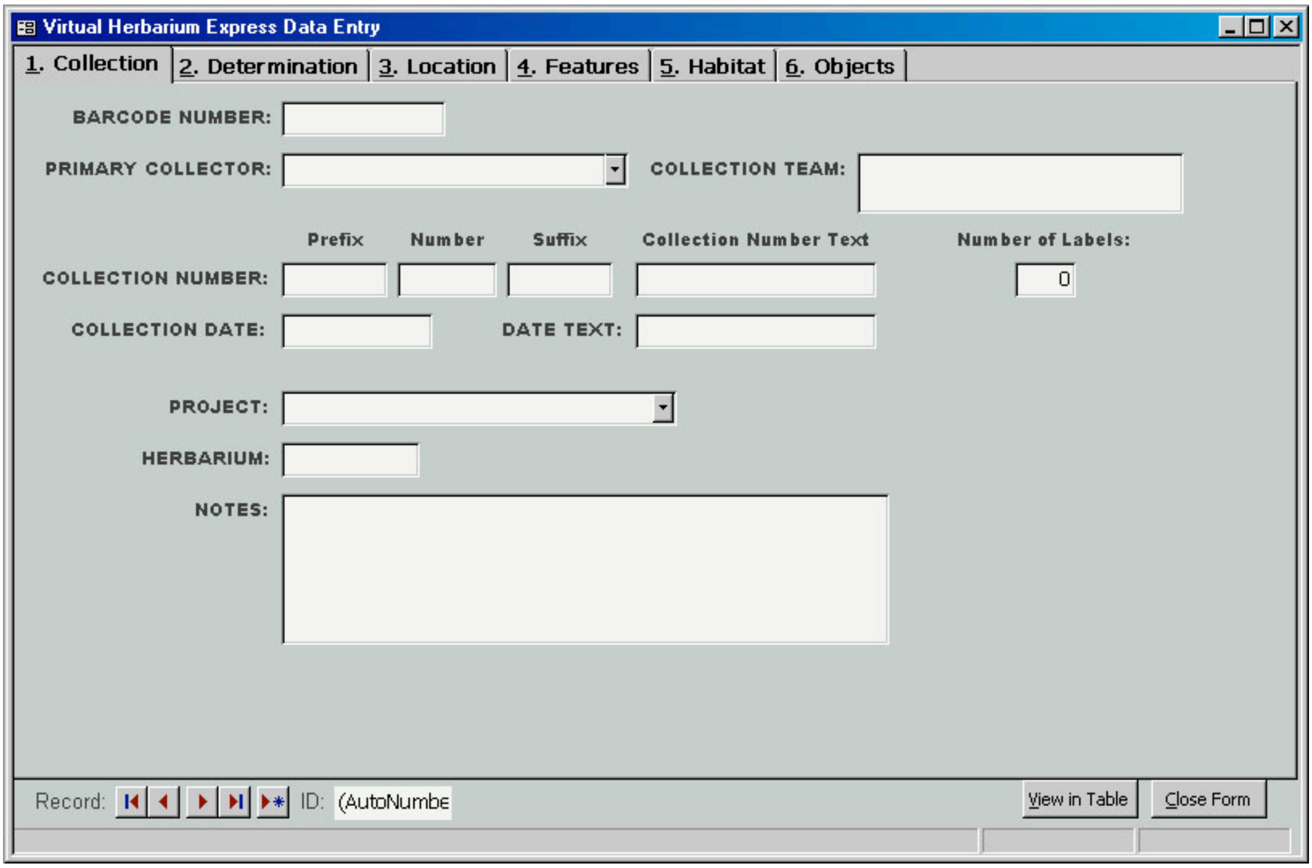
Dublin Core	
dc:Title	namesoup
dc:Creator	photographer
dc:Subject	---
dc:Description	caption
dc:Publisher	SEB
dc:Contributor	contributor
dc:Date	photo_date
dc:Type	---
dc:Format	jpeg,
dc:Identifier	local_ID

dc:Source	---
dc:Language	---
dc:Relation	collection
dc:Coverage	location
dc:Rights	photo_date
dc:Title	---

3.4 Voucher Specimens and Ethnopharmacological data

The collection of vouchers has always been a *sine qua non* for ethnopharmacology research as taxonomic identification constitutes the critical link between bioscientific and indigenous knowledge and allows comparisons across diverse cultures and vernaculars. They physically and permanently support data and form the basis for review and reassessment of the original study. Historically, the use and application of voucher specimens have been the greatest among biologists, specifically taxonomists. Consequently, they have been the developers of database software and set data standards for the management of these materials. Ethnopharmacological research, however, often requires additional types of data that are not compatible with current voucher database models such as a herbarium label database. Additional ethnopharmacological data often collected includes multiple vernacular names along with the specific language and etymology. Specific cultural terms or classes are commonly recorded in the language used to obtain the information, and the original natural language should be retained. Often a summary or interpretation of these data is recorded in the investigators native language. As a result, herbarium label databases often do not allow for the inclusion of ethnopharmacological data such as folk classification, use or indications, contra indications. Often only a simple notes or comment field is available which only permits a limited amount of text. An example of a new freely available herbarium database is the Virtual Herbarium Express (Figure 2). This software application was designed and developed by New York Botanical Garden scientists for use in botanical field research. It is designed in the popular Microsoft Access XP format and can run as a standalone application on a desktop or notebook computer. Developed as an electronic fieldbook, it is capable of recording necessary botanical voucher information. Instead of writing information in a notebook, later to be transcribed into a database, users can now create and maintain the database in the field. Collection information is entered in a simple data-entry form and stored in relational tables. The form contains six screens accessible by tabs at the top of the form. These screens - Collection, Determination, Location, Features, Habitat, and Objects - organize the more than 75 fields into a format promoting efficient data-entry. Extensive authority files buttress the system. These files are used to check the accuracy of the names of plants and people and publications as they are entered. (For example, the program comes with a table of over 71,000 people records and another of nearly 12,000 publications.) A small subset of output formats are also provided, allowing users to generate specimen labels, checklists, and collecting trip itineraries. Digital photos, or any other electronic file, can also be attached to each record, providing data otherwise unavailable or unconnected to a database. This collection information can then be used to print labels and other reports. Although a new powerful field tool with an application for ethnopharmacological research, its falls short in meeting the needs of an ethnopharmacological researcher since no pharmacological data fields exist. Although current funding does not permit active customization support for Virtual Herbarium Express, a modified version of this database including standard data fields pertinent to ethnopharmacological research is under discussion.

Figure 2. Screen Shot of NYBG Virtual Herbarium Express software.



It has been recognized that the standardization of terms and a unified system to describe and record ethnopharmacological data such as medicinal plant uses would be of enormous benefit to researchers, especially where exchanges of data sets are involved. One such standard is the Economic Botany Standard developed by the International Working Group on Taxonomic Databases for Plant Sciences (TDWG) which has been adopted as a standard by the International Union of Biological Sciences (IUBS) Taxonomic Databases Working Group. This standard provides a mechanism whereby uses of plants (in their cultural context) can be described, using standardized descriptors and terms, and attached to taxonomic data sets. However, attempts to utilize a standardized schema have not been widely implemented nor fully realized for several reasons. First, the Economic Botany Data Collection Standard is not very flexible because it does not allow users to extend the range of terms beyond what is defined, and it also contains inconsistencies. Second, implementing the standard into a relational format is an awkward step. Thirdly, it was designed not as a single unifying database but rather as a tool for potential users to consult in development of independent economic botany databases. The TDWG Economic Botany Subgroup has continued to periodically evaluate, revise and modify the extent to which the standard meets the needs of users. But the majority of the users have only implemented the highest level 1 classifications (Table 2) and have chosen to develop alternative classifications and definitions of ethnobotanical uses pertaining to institutional legacy data. Although the TDWG EBDS has not been fully implemented by a core network of researchers, it has raised the awareness and created much needed dialogue and discussion on ethnopharmacological and ethnobiological data standards.

Table 2. Economic Botany Data Standard - Level 1 states

0100 FOOD
0200 FOOD ADDITIVES
0300 ANIMAL FOOD
0400 BEE PLANTS

0500 INVERTEBRATE FOOD
0600 MATERIALS
0700 FUELS
0800 SOCIAL USES
0900 VERTEBRATE POISONS
1000 NON-VERTEBRATE POISONS
1100 MEDICINES
1200 ENVIRONMENTAL USES
1300 GENE SOURCES

An international standards committee or network remains to be formed to review a common shared model and meta-data descriptors despite the ongoing development of alternative database models for integrating and facilitating collaborative ethnopharmacological research.

A model for a database system that provides a standardized environment for submission, storage, and retrieval of ethnomedicinal data has been developed. The model is based on object oriented database technology, and is suitable for not only storing data, digital images, sound and video, but also for modeling domain knowledge associated with plant-based medicinal preparations utilized in systems of traditional medicine. The model incorporates both linguistic and semantic elements. Terms in natural language are mapped to database objects that represent knowledge in various ethnomedicinal domains. The distributed object infrastructure permits integration with other authoritative taxonomic databases and includes an interface capable of supporting existing and emerging standards of data. The model provides a foundation for a globally current dynamic data resource that encourages comparative ethnomedicinal research through direct contributions by members of the research community.

An example of a data object for a medicinal plant specimen is shown in Figure 3, which illustrates several characteristics of an object. The criteria used to determine what properties should appear in an object are based on standard data modeling techniques, and depend of course on the particular entity being represented by the object as well as the purpose for building the database. First, an object has a name (Voucher MT543) that uniquely identifies the object. Objects also have properties, in this case plant characteristics such as height. Properties have values, as in this case, the height is ca. 3.5 to 12 m. Objects have parts (leaves, flowers), and parts also have properties. In addition, objects have relationships with other objects. In this example, the specimen is related to more general classes taxonomically, and may have more specific species or cultivars, as indicated by "Superclasses" and "Subclasses". The superclass/subclass relationships result in taxonomies of objects which can be quite large (thousands of objects arranged in many classes). In general, an object has a unique name, properties, parts, associations with other objects, and general/specific relationships with other objects.

Figure 3. Object Representation of a Medicinal Plant Collected in Brazil.

Voucher MT543
Superclasses: Family Anacardiaceae
Subclasses: Plant Name - Genus/ Species/ Authority*: Anacardium occidentale* L.
a cultivar type – *var. bahiaensis*
Common name(s): cashew, cashew apple, cashew nut
Ethnic name(s): cajueira, cajú
Locality: Pataxo Indigena Reserva
County/municipality: Porto Seguro
State: Bahia
Country: Brazil
Lat: 16^{o} 51' S
Long: 39^{o} 09' W

Elevation: 20 m absl
Description: Along footpath leading to Posto. Open field. ca. 3.5 m
Habit: Spreading evergreen perennial tree
Height: *ca*. 3.5 to 12 m tall
Leaves: {Leaf Arrangement: Alternate Size: 10cm}
Flowers: {Petal Arrangement: Cluster: Color: White}
Fruit: short oblong, rounded with much swollen pedicel and apically curved; red to yellow
Cultivated: no
Collector: M.B. Thomas
Collection number: MT543
Date Collected: 16 September 1998
Photo(s): Entire Plant, Voucher, Leaf, Flower, Fruit, Voucher specimen, Collaborator images
Illustration(s):

As the object data modeling language is quite general, it can be applied to many different subjects. By using association relationships, objects from within and between different disciplines can be interrelated. Object models can be built in each of several different disciplines related to ethnopharmacology and these disciplines can be integrated via object associations. The disciplines involved include plant use categories and terminology, in which case the object database is used to describe a thesaurus and glossary of related terms. Systematics is treated by using object classes to describe ordinal, family, genus, species relationships, and the taxonomic structure of the object database lends itself well to this task. Several interesting problems in systematics, including cross referencing indigenous folk taxonomies with scientific models **,** and interrelating different taxonomic conventions, and tracking dynamic changes in the taxonomy, are also addressed. Ecology is treated by using object classes to describe 867 ecoregions proposed by the World Wildlife Fund. Phytochemical descriptions and relationships needed in ethnopharmacology are also handled using object descriptions of chemical properties and association among bioactive compounds.

The research presented here is intended for use by ethnopharmacologists, with the goal of developing and disseminating research data and exchanging knowledge among researchers. High-level data design and visualization tools can be used by researchers for browsing, editing, and efficient data entry. Using the object paradigm, researchers deal with objects that relate to their discipline, and therefore are easily recognizable. The visualization tools present the objects in a familiar form. These tools are accessible through a Web browser.

The approach goes beyond traditional collections management software such as BG-BASE (www.bg-base.com)**,** Specify (usobi.org/specify) and Biotica (viceroy.eeb.uconn.edu/Biota) by attempting to capture the interdisciplinary ethnobiology knowledge associated with specimens in addition to the specimen data.

4. Conclusions and Future Challenges

Recently, the formation of an ad-hoc working group called Collections of Ethno and Economic Botany (CEEB) within the Society for Economic Botany has been initiated. The development of a proposal to set standards of curation, form and implement a global network of collections and create a database of these collections in such a way that they are available online and can be interlinked as a specimen based searchable database has also been completed.

Additionally, the outcome of a recent National Science Foundation sponsored workshop (April 2002), attended by more than 30 mid-career ethnobiologists, was the consensus that much of the ethnobiological research of tomorrow will arise through discovery based upon collaborative research and shared information contained within community accessible databases. It was therefore, unanimously agreed that ethnobiological sciences have become increasingly data rich and future progress in ethnobiological research will depend upon the ability of the scientific community to both deposit and utilize digital data on-line. As a result, an initiative to create a database model for a Ethnobiological Expertise Directory (EED) as a community resource was formed. It is planned that the EED will serve as a global directory of ethnobiology specialists including both professionals and students. The creation of a community specialist directory will be propagated through a membership data-sharing partnership between the International Society for Ethnobiology and the Society for Economic Botany. This alliance will assist in rapidly propagating the proposed Ethnobiology Specialist database with an established user-base resulting in the rapid development of a community of scientists numbering more than 1000 members. It is also envisioned that its development will also be integrated in part to support the National Biological Information Infrastructure.

The development of such an international public Internet resource will establish a long-term sustainable community resource for both the scientific community and the broader public. The proposed community database is a much needed resource which will create greater interactions between the Ethnobiological community and other scientific communities and facilitate the exchange of ideas among those involved in field of ethnobiology. The data model currently under development contains secure ID implementation, a region for displaying individual research, bibliographic display, recent published thesis and dissertation abstracts, contact information and query of current research profiles by geographic expertise, ecological expertise (ecoregions), cultural group (language family) expertise and taxonomic expertise.

Equipped with modern scientific tools from molecular biology, analytical chemistry, and medical anthropology, ethnopharmacologists are asking a broad range of novel questions. However, the lack of a unified approach and standard data model has led to a paucity of comparative research – studies that not only examine different uses of the same type of plants in different cultures, but also compare the ways plants figure across cultures. Few studies have addressed the comparative analysis of possible patterns of medicinal plant selection by humans across cultures, regions or hemispheres. Indeed the absence of readily accessible comparative sources of ethnomedicinal data has been recognized as a serious hindrance. While the amalgamation of many different backgrounds and disciplines has enriched ethnosciences, the lack of a clear consensus on such basic issues as disciplinary goals and archiving methodologies has hampered the development of a unified and collaborative approach. The need for a standardized tool for archiving traditional knowledge would encourage a unified approach by facilitating a greater opportunity for comparative ethnopharmacological research through direct contributions by members of the scientific research community.

Ethnopharmacology is a field growing rapidly in research and in student and public interest within the United States and globally. There is an immediate need to focus and integrate modern information technology with methodologies appropriate for studying plant/animal-people interactions. In order to facilitate the growth and maturation of ethnopharmacology, we suggest new methodology of data collection, storage and retrieval which integrates research-based activities with educational activities. We hope this will further encourage the scholarly community to develop collaborative partnerships and conduct cross-cutting research, especially inquiries which broaden our theoretical understanding in this exciting and developing discipline.

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