Modern ethnobotany in low-income countries: use what is available and use it well.

Linh Ngo[1]

[1]*Genetics Area Program, University of Missouri, Columbia, MO 65201*

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*To whom correspondence should be addressed: Linh Ngo, Genetics Area Program, 241 Engineering Building West – University of Missouri, Columbia. Phone: (573) 882-1946. Email: ltn887@mail.missouri.edu.

Abstract: Recent years have observed a revival of interest in ethnobotany, the study of the relationships between plants and people. Ethnobotany research focuses on indigenous and traditional perceptions and usages of plants as food, fuel, and medicines across cultures. Ethnobotany is deeply rooted in daily routines, especially in countries that possess rich biodiversity and indigenous knowledge such as Vietnam. However, in order to be acknowledged as a formal and applied science, ethnobotany requires systematic research methodology. Ethnobotanical research methods should aim at collection high-quality, representative data that have statistical power. In this paper, the author emphasizes the importance of analytical research methods in ethnobotany, and provides basic references regarding this topic.

In low-income countries, ethnobotany is highly practical and strongly tied to culture and biodiversity conservation policies. As bulk investments into research expenses are frequently not available, the author proposes alternative solutions to improve ethnobotanical research quality: training for young scientists, and uses of available information resources.

Tóm tắt: Thực vật học dân tộc là một lĩnh vực "cũ mà mới". Đối tượng nghiên cứu của ngành này là mối quan hệ giữa con người và các loài thực vật, cụ thể là các phương thức dân tộc cổ truyền trong chế biến và sử dụng thực vật làm thức ăn, thuốc chữa bệnh, nguyên nhiên liệu và các mục đích khác. Ở những quốc gia phong phú về đa dạng sinh học và giàu có về kiến thức bản địa như Việt Nam, thực vật học dân tộc đã hòa trộn vào cuộc sống từ lâu đời. Tuy nhiên, để được thừa nhận là một ngành khoa học nghiêm túc và có tính thực tiễn cao, các nhà nghiên cứu thực vật học dân tộc cần có phương pháp nghiên cứu khoa học mang tính hệ thống. Các phương pháp này nhằm thu thập thông tin có chất lượng cao, mang tính đại diện và tính thống kê cao. Các nhà nghiên cứu thực vật học dân tộc cần được đào tạo về thiết kế nghiên cứu và xử lý dữ liệu. Trong bài viết này, tác giả nhấn mạnh tầm quan trọng của phương pháp nghiên cứu trong thực vật học dân tộc và cung cấp các tài liệu cơ bản hướng dẫn cụ thể về lĩnh vực này.

Ở nhiều nước thu nhập thấp, thực vật học dân tộc là ngành nghiên cứu gần gũi với cuộc sống, đồng thời gắn bó chặt chẽ với công tác hoạch định chính sách, bảo tồn đa dạng sinh học và bảo tồn văn hóa bản địa. Tác giả bài viết này không chủ định kêu gọi đầu tư về thiết bị và công nghệ cho lĩnh vực này mà ngược lại, nhấn mạnh vào việc tận dụng kho dữ liệu có sẵn để xử lý và mở rộng thông tin. Chất lượng nghiên cứu trong thực vật học dân tộc sẽ nhờ đó mà được cải thiện đáng kể.

Keywords: Ethnobotany, research methods, information resources.

Introduction

Ethnobotany as the study of the relationship between humans and plants has played a central role in understanding how plants are used as important sources of food, fiber, fuel, construction materials, cosmetics, and medicines (1-3). Wikipedia describes ethnobotanists as people who "aim to document, describe and explain complex relationships between cultures and (uses of) plants, focusing primarily on how plants are used, managed and perceived across human societies". This description is very close to one's imagination of a nature explorer who goes to exotic places and records how ethnic people use plants in their unique ways. What makes an ethnobotanist different from a nature explorer? As interesting as an article about plants and cultures in a nature explorer's magazine can be, it is mainly descriptive, that is, the information is not necessarily reproducible, representative, nor applicable. An ethnobotanist, in contrast, is a multidisciplinary scientist who should be able to conduct well-designed research that produces high-quality data (5). In fact, "ethnobotany" is a combination of two sciences, ethnology (the study of culture) and botany (the study of plants), and therefore should be considered a respectable science with its own methodology.

Once high-quality data is produced, ethnobotanists should be able to assemble this into "the big picture". Ethnobotany, as a research science, is struggling with the same issue as many research fields: the breadth of assembled information is not equivalent to the depth of such information. Ethnobotanists usually understand how a group of plants is used in a small geographic area where their research focuses; however, they are rather slow on synthesizing their own information with other related data in both temporal and spatial scales (6). Their stories are therefore relatively specific and not as applicable and valuable as they could be. Ethnobotanical databases are available and usable, yet the majority of these are still limited in accessibility, vague in the level of details, and constricted in the scope of data (6, 7).

Generally, there are two important kinds of resources that ethnobotany directly handles: the biodiversity of plants and related biotic interactions, and the traditional knowledge of using plants. Both of these resources are declining at an alarming rate, making the need of understanding and managing them in a sustainable manner more urgent (8). It is inevitable that ethnobotany ought to develop into a respectable science that connects strongly with conservation and sustainable development. Modern technologies such as genomics, proteomics, metabolomics, and bioinformatics have been tremendously valuable in transforming other branches of biology, yet their applications in ethnobotany have been limited (9). The major reasons are the significant cost, the complex infrastructure, and the need for well-trained personnel required to establish and implement such technologies. Considering that the richness of biodiversity and traditional knowledge is much higher in tropical, low-income countries, the hindrances of applying modern technologies to study and manage these resources become even more significant (9). In these countries, supplying ethnobotanical research centers with state-of-the-art instruments and training researchers to use them skillfully are not likely to be feasible approaches in the short term. The ideal solutions ought to be relatively inexpensive and simple, yet capable of improving the quality of ethnobotanical research significantly.

This paper aims to suggest potential improvements of ethnobotany in low-income countries. The paper focuses on 3 main discussions:

i. The importance of quantitative methodology in ethnobotany
ii. The assembly of ethnobotanical data and the usage of databases
iii. The development and potential usage of modern technologies in ethnobotany

With the emphasis on low-income countries, the ultimate objective of this paper is to argue that low-cost and high-quality ethnobotanical research is possible. A combination of sustainable interest, education, training, and information accessibility and technology transferability can help move this field forward a long way.

The importance of quantitative methodology in ethnobotanical research

Ethnobotany could be considered an ancient field of study as it covers the relationships between plants and people, which have existed and played important roles throughout human history (1). For a brief chronology of milestones in the field, refer to Paye's book "Cultural Uses of Plants – a guide to learning about ethnobotany" (2000). The term "ethnobotany" was coined in 1895 by Harshberger. The American botanist defined ethnobotany as "the study of the utilitarian relationship between human beings and vegetation in their environment, including medicinal uses" (11). The definition has changed over time, but the core concept remains the study of plants and people who use them (3). Ethnobotanical works involved mostly list-making, until a scientific methodology was established in the 1940s by Schultes (12). He is considered the father of modern ethnobotany for his empirical research on hallucinogenic plants in the Amazon rainforest (3). Instead of making lists from local interviews, Schultes pioneered in representative survey methods that "sample" an adequate number of interviewees (13). He also emphasized the importance of biochemical assays in his studies and contributed to the discovery of lysergic acid diethylamide, or LSD, by Albert Hofmann (14).

Since then, ethnobotanists have recognized the importance of quantitative methods and well-designed studies in this rather "flexible" science. Indeed, without quantitative assays and methodical approaches that produce high-quality, reproducible, and representative data, ethnobotany could be easily mistaken for a career of nature explorers or culture/plant enthusiasts. First and foremost, ethnobotanists ought to be trained in quantitative methodology and critical thinking as thoroughly as scientists in other fields (13). They should then be able to apply the methods to their own researches. As ethnobotanical projects are very different from one another, developing single standard methodology is not feasible. However, scientists should be able to design their own approaches in order to produce representative and reproducible data (15).

Intensive training is important for young ethnobotanists, even though it is not always available. There are very few programs with an emphasis in ethnobotany; therefore young scientists usually have to either "design" their own curriculum within a related field, or become a self-learner. Regarding quantitative methodology in ethnobotany, one could refer to respectable resources such as: "Ethnobotany: A method manual" by Gary Martin (book, 1995), "Selected guidelines for ethnobotanical research: A field manual" by Miguel Alexiades (book, 1996), "Ethnobiology" edited by Anderson et al. (book, 2011), and the website "UHM Quantitative Ethnobotany" (https://sites.google.com/site/uhmquantitativeethnobotany/) by the University of Hawaii – Manoa (16). The multidisciplinary nature of ethnobotany requires researchers to acquire multiple skill sets and to collaborate with experts from related fields in order to design and conduct successful studies (13).

Ethnobotanical studies usually involve traveling to remote research locations, dealing with new plants and cultures, and handling unexpected conditions (2). All of these circumstances require carefully designed research plans, which allow researchers to conduct the studies with confidence that collected data is high-quality, representative, and reproducible. Yet such plans should be adequately flexible to permit the researcher to handle unpredictable situations, e.g. weather conditions, plant growth season, and unique cultural patterns. Thorough review of available literature and collection of "gray information"(unpublished data or non-scientific facts) is strongly recommended. One could collect gray information from general media such as television and the Internet, from museums and cultural references, and from personal communication with experienced researchers. Application of statistical methods is crucial, as a statistically-sound research design allows the ethnobotanists to plan their surveys and experiments effectively and efficiently, so that the collected data can be interpreted in a meaningful manner (13, 15, 17).

Plant usages could be considered multidimensional phenomena that can be dissected, clustered, and interpreted in similar manners to complex traits or networks. Multidimensional data, complex traits and interactive networks are the exciting subjects of phenomics and genomics, which are very active research fields (9). Meanwhile, studies of plant usages are still in their early stage of developing quantitative methods. Weckerle et al. (17) in a recent publication described how their group used a Bayesian approach to compare the medicinal flora with the overall flora of Campania, Italy. The statistical methods enabled them to survey overused and underused species, as well as to determine the correlation between medicinal uses and taxonomical groups. Hoft et al. (1999) reviewed multivariate analysis in ethnobotany (18), which should be used as a respectable guideline in designing and analyzing ethnobotanical studies.

The assembly of ethnobotanical data: how to make (more) sense of data in the big picture

Once high-quality data has been generated, it should be assembled and organized in a systematic manner to create broader impacts. Even sophisticated, well-conducted ethnobotanical works are rarely sufficient to result in direct decisions, such as conservation plans, policy changes, drug discovery, or drug safety and efficacy confirmation. The option of integrating, comparing, and assembling specific data sets enables ethnobotanists to broaden the impacts of their research (6). The available databases and tools allow such processes to be performed at low cost, given that awareness and training to use such resources are provided.

Botanical data

A required component of most ethnobotanical studies is to collect and annotate botanical specimens of the plant species of interest. Once accurate annotations of botanical specimens are made, the plant species should be examined in their phylogenetic and biological contexts. First, the scientific names of the species must be listed correctly, using respectable references, such as TROPICOS (www.tropicos.org). Researchers should be aware of existing synonyms and other common names of the species in order to make literature mining possible and complete. Botanical revisions provide frequent updates, and therefore researchers should assume the responsibility to cope with such changes (20). Ethnobotanical surveys and collections could in turn provide a valuable means to revisit botanical information of both known and understudied species.

After obtaining accurate botanical annotations, the researcher could proceed to examine the phylogenetic relationships between the plants of interest and other groups. Phylogenetic analysis is helpful in several ways:

i. It places the particular species into a larger context of taxonomy, and therefore missing information about biology and botany of such species could be inferred from the characteristic patterns. For example, a researcher could retrieve the general botanical patterns of an incomplete specimen that only allows him to determine its taxonomy to family or genus level.
ii. It recognizes the species as a part of the genus/family/other levels of taxonomy and helps better understand the biology and importance of these groups. For instance, Asteraceae is one of the most widely studied families for its vast diversity in morphology and usages (21).
iii. It helps connect understudied species/groups to those with a wealth of information. In a recent study, new varieties and landraces of wormwood (*Artemisia annua L.*) were collected, screened and crossed to breed high artemisinin yielding plants (22). The exciting research on artemisinin as a valuable malaria treatment created the need of searching for breeding materials among the diverse landraces, which would have remained unknown otherwise.
iv. It provides insights into the putative evolutionary timeline of the species of interest, which may be correlated to the history of its adoption and usage by people. The evolution of corn (*Zea mays*) is known to be strongly tied to domestication and artificial selection over approximately 4500 years (23, 24).

TROPICOS provides good phylogenetic presentations of searched species by providing a taxonomy browser with easy-to-use organization (see Figure 1). Pictures of real plants and herbarium specimens are also available for references. TROPICOS offers an abundance of information related to describe species that could be mined, such as distribution and relevant publications. It also provides tools that could be readily used, for example, DNA specimen search, ethnobotany, and specimen geographic search. Another resource called The Plant List (www.theplantlist.org) is especially helpful in gathering available information into one place, and providing meaningful taxonomical statistics. A certain level of training is necessary to help ethnobotanists, especially in low-income countries, to use these resources. Once researchers are aware of these resources and how to use them, their data sets could be assembled and interpreted in a much more comprehensive manner.

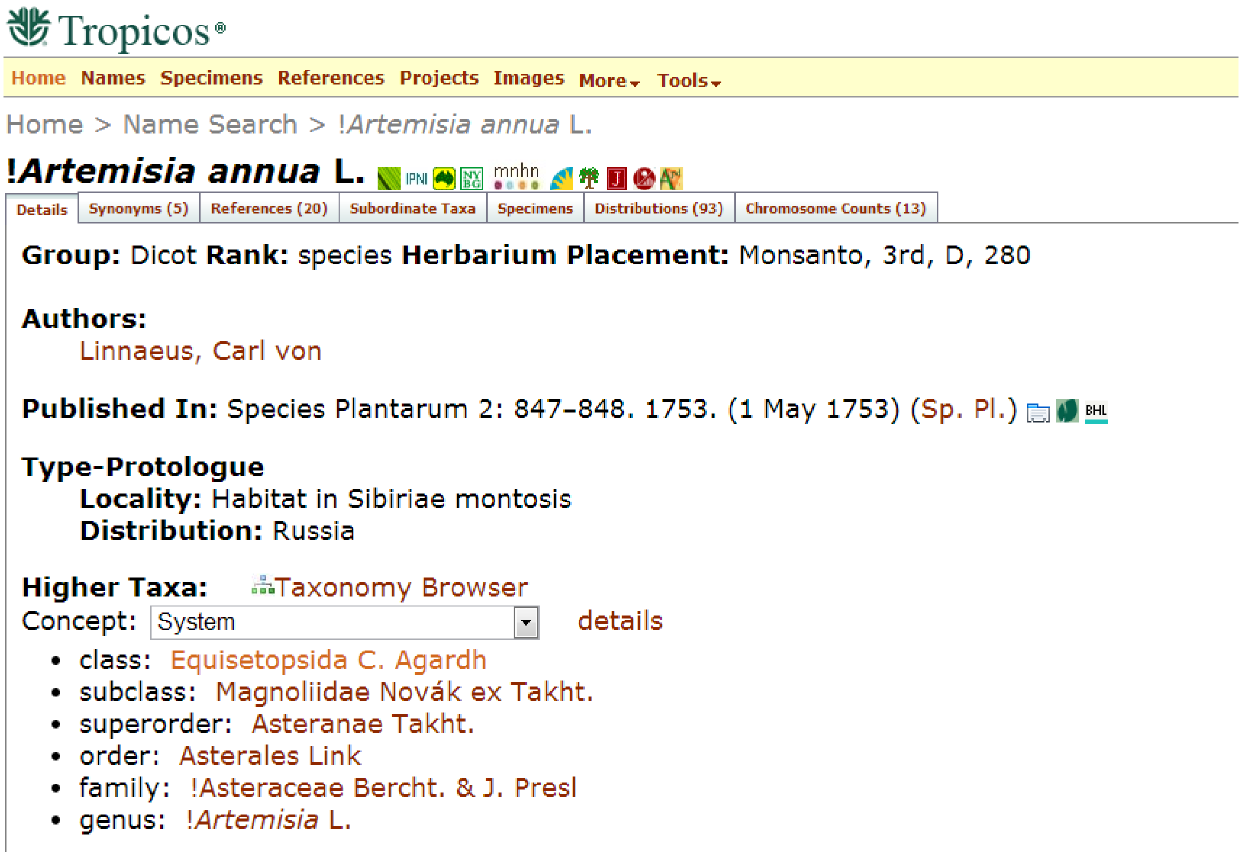

Figure 1: A part of the results page from a TROPICOS search. The tool bar is at the top of the page, under the Tropicos logo. The specific information navigation bar is under the species name. Taxonomic information of the searched entry is shown.

Ethnobotanical data

Ethnobotanical data is typically unique and complex, considering the multi-dimensionality of the cultures in which the plant species of interest are used and the significant variation of human-related information (13). Consequently, it is difficult to assemble such data into even broader databases or contexts. The resolution, i.e. the level of detail, of ethnobotanical data is reduced significantly when assembled into databases (6, 7). Even when data is successfully assembled, databases are often not comparable due to differences in emphases and methodologies, to missing information, or to lack of accessibility (6, 7).

Despite the above challenges, several ethnobotanical databases have been made available and are becoming increasingly useful in helping researchers gain further insights into their species of interest. Thomas (2003) has summarized the current digital databases and recognized their insufficiency. The author also suggested a “coordinated global approach” to manage the growing amount of ethnobotanical information worldwide. A more updated list was composed by Ningthoujam et al. (2012), yet the challenges of developing robust, comprehensive, coordinated databases were still recognized.

Several outstanding examples of ethnobotanical databases are the University of California Riverside's Ethnobotany Database, NAPRALERT, Dr. Duke's Databases, and the International Ethnobotany Database (ebDB). The UC Riverside's Ethnobotany Database (26), despite its great coverage of information, has two significant shortcomings: i) It is an off-line tool and therefore accessibility is very limited, and ii) It is a closed system that does not allow data to be shared, downloaded, or added. NAPRALERT (27) is no doubt a very informative and well-organized database, yet access is not free. This database also focuses strongly on phytochemistry of listed plants and therefore becomes somewhat narrow for ethnobotanists' uses. Dr. Duke's Phytochemical and Ethnobotanical Databases (28) has a large coverage with relatively complete data on most entries. The website is very user friendly, free, and accessible online. However, the ethnobotanical data on this database is very limited to Dr. Duke's work, and would not efficiently assist other researchers in disseminating their own works.

The ebDB (www.ebdb.org) is a recent database that was completed and made publicly available in 2006 (29). This is a pure ethnobotanical database, that is, it is not a one-stop shop for researchers who expect a full spectrum of information from botany to phytochemistry. Getting access to this database does not seem to be straightforward at first, as it has a unique system to manage information ownership. Nonetheless, ebDB is an informative, well-organized, free international database. ebDB has several note-worthy features: multilingual search, dataset management of accessibility and control of information, broad ethnographic information, data export, field research, and other tools. A detailed report and tutorial of this database was compiled by Skoczen and Bussmann (2006).

Even though the need of developing a fully accessible, comprehensive, international database is still pressing, updating and using current databases is strongly recommended. From the perspectives of either a student beginning to do research or an experienced ethnobotanist, these databases could provide valuable information that forms the background of their studies, reduces the number of hypotheses to be tested, or suggests intriguing ideas of how to interpret their specific data.

Omics tools and ethnobotany

Genomics, proteomics, metabolomics and phenomics, or "omics" technologies, aim to unravel the complete profiles of genes, proteins, metabolites and phenotypes, respectively (30). These modern and robust technologies have been tremendously helpful in elucidating gene networks, protein interactions, metabolite synthesis pathways, and complex phenotypes. However, the costs of these technologies are still very high and therefore, in plant science, they are used mainly to study the biology of major food crops. The transferability of these technologies to ethnobotany is promising (9, 30)yet not readily feasible in the near future, especially in low-income countries. The major hindrances of implementing 'omics' technologies in such countries are: (i) the cost to initiate and maintain the required infrastructure, and (ii) the lack of advanced technical training. Nonetheless, the advantages of implementing 'omics' technologies in ethnobotany are apparent. Researchers could gain much deeper insights into the chemistry and biology of the plants of interest (30). The efficacy and safety of ethnomedicinal therapies could be evaluated in a much faster pace (31). Whole-genome plant systematics enables the discoveries of new patterns in ethnobotany that could not be obtained at such large scales in the past (32). Several reviews with great details about omics technologies and potential applications in ethnobotany have been published (9,30,33-35).

While the establishment of 'omics' technologies in low-income countries is likely to take a significant amount of time, effort, and financial investment, several databases resulting from 'omics' research have been made available. Databases on model plants (*Arabidopsis*) and important crops (maize, soybean, rice) are available online at little to no cost, with immense depth and abundance of usable information. Databases on medicinal plants, such as the Medicinal Plant Genomics Resources (http://medicinalplantgenomics.msu.edu/), have been recently developed and made available. Ethnobotanists should take advantage of the accessible data and tools, as these resources are very applicable and likely to provide more insights into their own research.

Conclusion

Ethnobotany is an important field of study that focuses on the dynamic and complex relationships between plants and people. This paper argues that the improvement of ethnobotany as a respectable, quantitative science in low-income countries is possible. The major suggestions are employment of quantitative methodology, improvement of training for ethnobotanists, and utilizing available resources to produce high-quality, representative, reproducible data. In the longer term, much effort is necessary to establish curriculums to train ethnobotanists, to improve databases, and to implement modern technologies in ethnobotanical research.

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About the author: Linh Ngo is a PhD student is the Genetics Area Program at the University of Missouri, Columbia. She received her BSc in Crop Science from the adjunct program between Hanoi University of Agriculture and University of California, Davis. Linh has spent several years doing in situ ethnobotany research in Ta Phin (Sa Pa – Lao Cai), Vietnam. She was the first author of a review article on natural product research (http://www.ncbi.nlm.nih.gov/pubmed/23450245). Currently, Linh is working on her PhD dissertation on genetic networks of complex phenotypes (http://www.maizelesions.org/kazic.html), and assisting a community project in Ta Phin (http://www.reddreamproject.com/).