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Ethnobotanical methods used for the study of medicinal plants: Approaches for Sampling and Collecting Ethnobotanical Data (part I)

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Abstract: Ethnobotany has evolved from its original definition as the study of plant utilization among indigenous populations to a multidimensional field encompassing complex relationships between plant diversity and culture. Sampling and data collection methods hold paramount importance in ensuring the reliability and rigor of conclusions drawn from gathered data. The interplay of quantitative and qualitative approaches within ethnobotanical research allows for a comprehensive exploration of the intricate connections between human communities and plants. The rarefaction curve emerges as a crucial analytical tool, aiding researchers in assessing sample adequacy and knowledge saturation. It enhances the quality of ethnobotanical surveys by guiding decisions on the continuation of data collection efforts and providing insights into plant biodiversity within a community. However, the choice of sampling methods must align with research objectives, whether quantitative or qualitative, to accurately capture the depth and breadth of ethnobotanical knowledge. Ethnobotanical research in Morocco exemplifies the application of diverse data collection methods, with the interview technique being the most prominent. While structured questionnaires offer standardized data, methods like Free Listing, Guided Tour, Participant Observation, and Group Discussion enrich the understanding of cultural plant practices. The incorporation of various techniques ensures a holistic grasp of ethnobotanical knowledge and facilitates cross-study comparisons. The methodologies employed in ethnobotanical research are pivotal for uncovering the intricate relationships between human populations and plants. A well-crafted sampling and data collection approach enhances the credibility and relevance of findings, contributing to a deeper appreciation of the vital interdependence between humans and their botanical environment.

1. Introduction

Initially, ethnobotany was defined as a scientific field that investigates the utilization of plants among indigenous populations (Harshberger, 1896; Ritter *et al.*, 2015) (Figure 1). This original definition has since evolved to include the study of complex connections between plant diversity and culture, as well as the intricate interplay of perceptions, uses, and plant management (Albuquerque and Hanazaki, 2009).

Ethnobotany is a specialized branch of ethnobiology that has garnered renewed interest over the past few decades (El Mernissi *et al.*, 2023; Chavda *et al.*, 2022; Bencheikh *et al.*, 2022; Ben Saleh *et al.*, 2016; Pei, 1995). Its significance becomes even more evident in developing countries, where it receives

growing attention. This is due to the fact that ethnobotanical research demands fewer financial resources and the local communities in these nations possess a wealth of traditional knowledge about their local flora and fauna. Consequently, ethnobiology as a whole, and specifically ethnobotany, are emerging as effective tools for fostering sustainable development in countries with limited resources (Houéhanou *et al.*, 2016) (Figure 2).

Figure 1. Relationship within ethnobiology, ethnobotany and ethnopharmacology

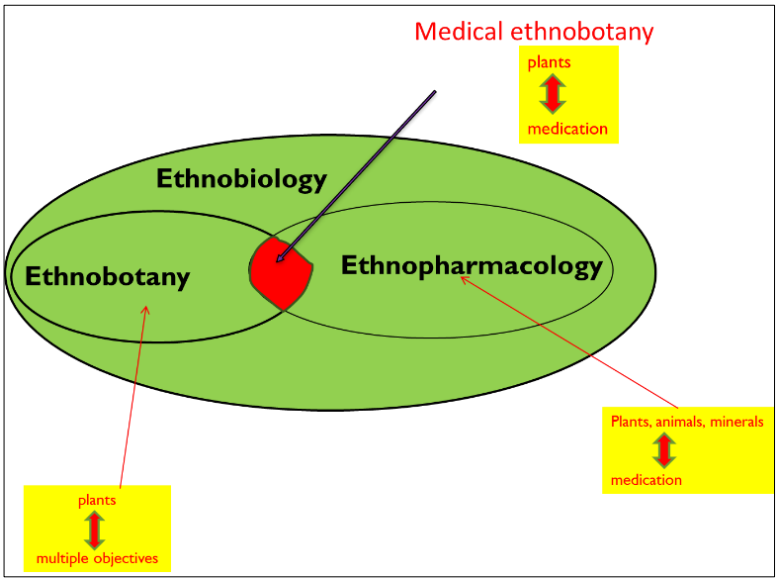

Figure 2. Harshberger is the first person to use the term ethnobotany

In the field of ethnobotany, various approaches are employed for the collection and analysis of both quantitative and qualitative data. These approaches are carefully chosen based on the specific objectives of the researcher and the unique nature of the ongoing study. The ultimate goal of these methods is to ensure an objective and rigorous evaluation of the reliability of the conclusions drawn from the gathered data (Takele Ashebo 2019; Kushwaha *et al.* 2018).

At the core of ethnobotanical study lies the necessity of gathering accurate and relevant data to gain a deeper insight into the intricate relationships between human populations and plants. Hence, sampling and data collection methods play a pivotal role in establishing a robust foundation for subsequent analyses. In this work, we delve into various approaches that steer the sample selection and data collection processes within the realm of ethnobotany.

2. Types of Ethnobotanical Data

Data collection aims to gather the information deemed essential for solving a research problem and can lead to the establishment of an extensive database. Data can be collected for various reasons. Data is categorized based on its origin, namely, primary data, which is newly generated during the research process, and secondary data, which already exists.

3. Sampling Methods

3.1 Secondary Data

Secondary information refers to data that already exist at the beginning of a research endeavor. Ethnobotanical secondary data are distinct from other data obtained by researchers engaged in fields related to ethnobotany, such as Historians, Climatologists, Archaeologists, Geographers, Botanists, Palynologists, Agronomists, Geneticists, Ethnographers, Travelers and Explorers, Thinkers, Philosophers, Writers and Narrators, Medical Practitioners and Pharmacognosists, Linguists, Technologists, Dietitians, Nutritionists and Ethnobotanists. Collecting secondary data involves assembling information that already exists. The judicious utilization of this type of information facilitates an introduction to the research issue and streamlines the research process. Furthermore, these data gain significance when compared or grouped together.

Numerous references regarding plants in Morocco and Algeria hold significant importance for researchers in ethnobotany within Morocco. Among the examples are the works of (Jahandiez and Maire, 1934, 1931, 1932; Emberger and Maire, 1941; Charnot, 1945; Maire, 1952; Quézel and Santa, 1962; Quezel and Santa, 1963; Ozenda, 1977; Bellakhdar J., 1978; Bellakhdar, 1986, 1997; Fennane, Tattou and Mathez, 1999; Fennane and Ibn Tattou, 2008; Fennane, Ibn Tattou and El Oualidi, 2014) (Figure 3).

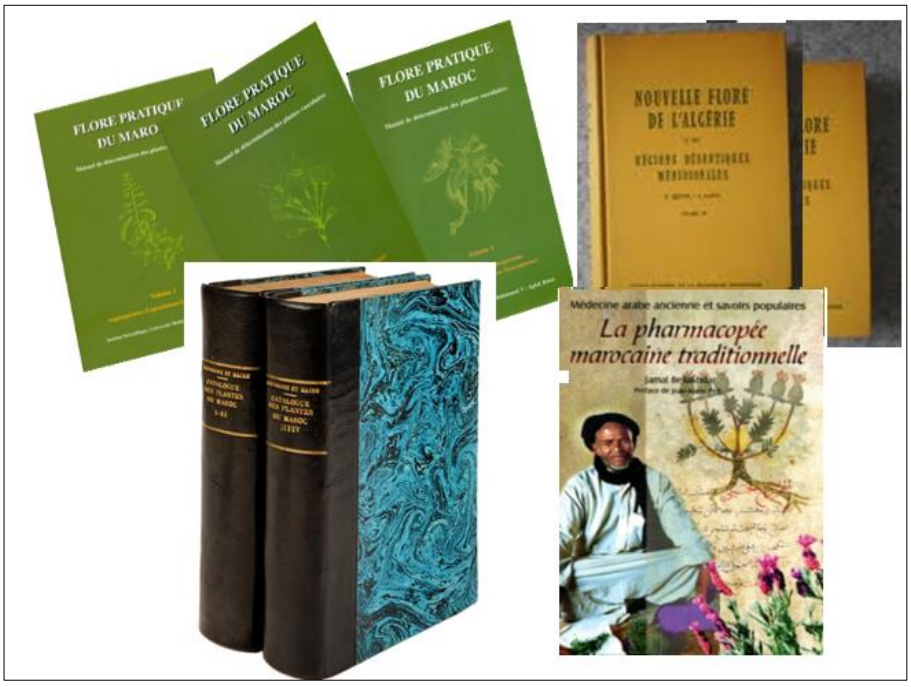

Figure 3. A few references that can be utilized to extract secondary data

3.2 Primary Data

In ethnobotany, two main categories of sampling are generally utilized: probability (random) sampling and non-probability (non-random) sampling.

3.2.1 Non-probability Sampling (Non-Random)

Non-probabilistic sampling methods play a significant role in the realm of ethnobotanical studies. These techniques are employed when the constraints of time, resources, or specific research objectives make it challenging to implement traditional probabilistic sampling approaches. Cochran's insights, as outlined in his 1977 work (Cochran, 1977), shed light on the various non-probabilistic sampling techniques that have become integral to ethnobotanical research.

One of these techniques is Convenience Sampling, which involves selecting any available subject for the study without following a specific sampling framework. This approach is particularly useful when rapid data collection is essential or when it is difficult to access a representative sample from the entire population. However, it's important to note that convenience sampling may introduce biases, as the participants may not accurately represent the broader population.

Quota Sampling, another technique highlighted by Cochran, offers a structured non-probabilistic approach. In this method, the population is divided into distinct groups or strata, and then participants are selected non-randomly from each group. This allows researchers to ensure a proportional representation of different segments of the population, making the sample more balanced and reflective of various characteristics. While quota sampling provides a level of control over the sample composition, it still falls under the category of non-probabilistic sampling, potentially limiting the generalizability of the findings.

Snowball Sampling is yet another non-probabilistic technique discussed by Cochran. This method is particularly advantageous when studying hidden or hard-to-reach populations within the context of ethnobotanical research. It involves identifying an initial knowledgeable informant, who is then interviewed. Subsequently, this informant refers the researcher to other knowledgeable individuals from the same community. This chain reaction of referrals creates a "snowball effect," leading to the investigation of multiple experts on the study's subject. While snowball sampling can be instrumental in exploring intricate networks of knowledge within communities, it must be employed cautiously to avoid overrepresentation or bias.

3.2.2 Probability Sampling (Random Sampling)

Probabilistic sampling methods are a cornerstone of research methodology, particularly in the realm of ethnobotanical studies. These techniques offer a systematic approach to selecting participants or subjects, ensuring that each element within the population has an equal and known opportunity to be included in the sample. In 2008, Levy and Lemeshow provided valuable insights (Levy and Lemeshow, 2008) into the most prevalent probabilistic sampling techniques, shedding light on the significance of their application.

Among these techniques, Simple Random Sampling stands out. Here, every individual in the population has an equal chance of being selected for the sample. This method ensures fairness and minimizes potential biases, allowing for unbiased representation and robust results. Each possible combination of population members is treated impartially, contributing to a representative sample that accurately reflects the population's diversity.

Stratified Random Sampling, another approach highlighted by Levy and Lemeshow, involves dividing the population into distinct and similar groups called strata. From each stratum, independent samples are drawn, enhancing the precision of the findings by capturing variations within different subgroups. This technique is particularly useful when certain characteristics of the population need to be properly represented in the sample.

Cluster Random Sampling takes a different route. It involves dividing the population into clusters or groups. A random selection of clusters is made, and all units within the selected clusters become part of the sample. This technique simplifies data collection, especially when dealing with large or geographically dispersed populations, as it reduces logistical challenges.

3.3 Rarefaction Curve: An Analytical Tool for Ethnobotanical Sampling Assessment

In the field of ethnobotany, the use of the rarefaction curve (or accumulation curves) proves invaluable for evaluating the relevance of the chosen sample, without necessitating a representative value with a 5% margin of error (Begossi, 1996). This approach is grounded in the number of informants per plant or the number of citations associated with each plant. In practice, sample adequacy is estimated when the curve reaches a plateau, indicating that the majority of plants and their uses have already been documented (Figure 4).

The rarefaction curve holds paramount significance in the design and execution of ethnobotanical surveys. It enables researchers to visualize the growth of the number of documented plants as new informants are incorporated into the study. Within the context of plant biodiversity, this method assumes particular relevance, providing a means to monitor the completeness of sampling and make informed decisions regarding the continuation of field data collection efforts (Alencar and Albuquerque, 2015).

The shape of the rarefaction curve also offers insights into the richness of plant biodiversity within a given community, as well as the effectiveness of sampling. If the curve rapidly levels off, it suggests that most plants have been documented, indicating adequate sampling. Conversely, if the curve continues to rise significantly even with the addition of more informants, it may imply that sampling is not yet comprehensive.

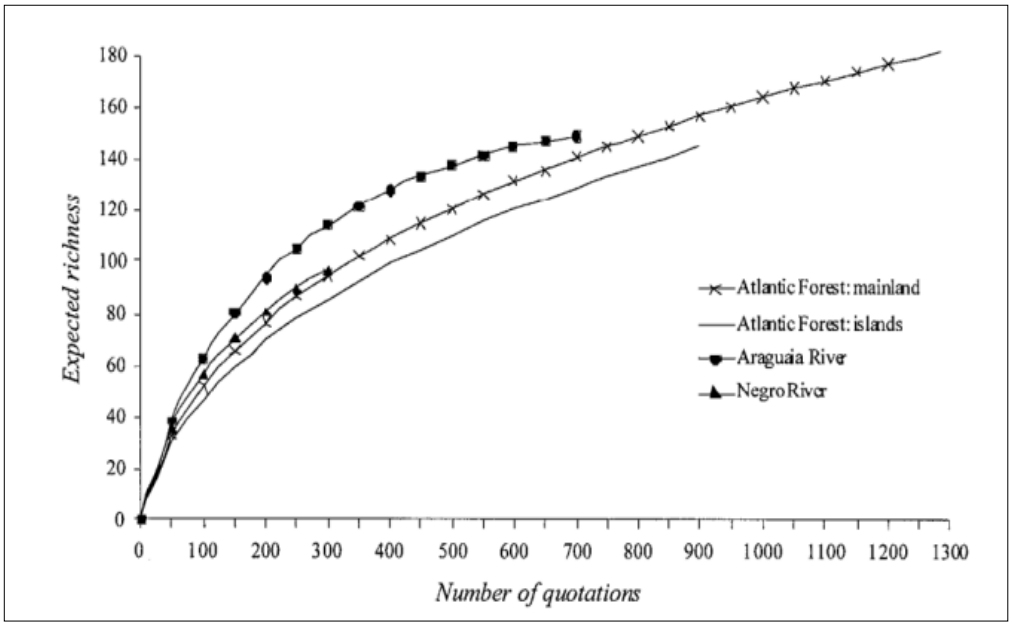

Figure 4. Rarefaction Curve according to Begossi in 2002 (Begossi, Hanazaki and Tamashiro., 2002)

However, it is important to note that the rarefaction curve provides an estimation of sampling completeness and does not necessarily ensure the identification of all important plants. Nevertheless, it guides researchers in making decisions to continue data collection or consider sampling as meeting their research objectives.

In conclusion, the rarefaction curve proves to be an invaluable tool for ethnobotanical researchers, offering visual and analytical insights to assess sample representativeness and information saturation. This approach enhances the quality and rigor of ethnobotanical studies, thereby contributing to a deeper understanding of interactions between human communities and plants in their natural environment.

3.4 Authentic Sampling Strategy in Ethnobotanical Investigations

In numerous instances, the application of sampling techniques in quantitative research is intertwined with the verification of hypotheses, exploration of behavioral patterns, and comparisons both within a study and across other studies. Within these contexts, the determination of sample size hinges on the quantity needed to facilitate credible references concerning the population or targeted group (Marshall, 1996). Consequently, a meticulouslycrafted sampling plan emerges as a pivotal stage in attaining the research goals associated with uncovering patterns and trends. The incorrect utilization of sampling methods could introduce biases that sway the acceptance or rejection of hypotheses and obscure behaviors, leading to an improper grasp of the internal diversity inherent in a given domain (Bartlett, Kotrlik and Higgins, 2001; Freiman et al., 1978).

However, the adequacy of the sample size in itself does not singularly ensure representativeness. Adhering to the principles of randomness is imperative to circumvent potential skewing of the sample by specific subsets. These presumptions commonly factor into quantitative research endeavors that aim to extrapolate findings.

Moreover, it is imperative to acknowledge that bona fide sampling strategies play a pivotal role in the precision and dependability of ethnobotanical investigations. Through the judicious application of suitable sampling techniques, researchers can guarantee that their findings faithfully reflect the intricate interplay between plant utilization and cultural practices within distinct populations.

In the field of ethnobotany, when individuals are interviewed and inquiries are directed towards specific knowledge, it is crucial to ensure that the chosen sample is genuinely representative. This involves including individuals from diverse social backgrounds, various age groups, and different genders. By doing so, we mitigate the risk of sample bias, ensuring that our findings are not unduly influenced by any particular demographic (Cunningham et al., 2015; Reyes-García et al., 2010).

In accordance with statistical principles, a sample is considered "representative" when it is chosen at random and the probability of distorting the overall universe is 5% or less (Bernard, 2006). These statistical considerations hold particular importance in quantitative research endeavors aimed at extrapolating results to broader populations.

The intricate interplay between ethnobotany and biodiversity conservation underscores the importance of sound sampling practices. Inadequate sampling methodologies can generate misleading insights into the conservation status of medicinal plants, potentially masking the strategic interventions required for their preservation. Moreover, an erroneous assessment of popular plant choices within a specific community, often selected for pharmacological studies, could result from improper sampling, leading to misguided interpretations (Thomas et al., 2015; Cámara-Leret et al., 2014).

Navigating these complexities within ethnobotanical research demands a deep understanding of the nuances of sampling. A well-designed sampling framework ensures that our exploration of plant knowledge, usage, and conservation is based on robust and precise methodologies, fostering a deeper comprehension of the delicate relationship between human communities and the plant world.

Owing to the substantial time and financial resources required, true random sampling is often unattainable in many applied research scenarios within the field of ethnobotany (Ladio, 2001; Alexiades and Sheldon, 1996). Consequently, a stratified random sampling strategy is commonly

employed to investigate plant usage. The stratified random sampling technique involves identifying distinct groups or strata within the population based on criteria such as ethnicity, gender, age, economic activity, among others (Begossi, Hanazaki and Tamashiro, 2010; McCorkle, Mathias-Mundy and McPherson, 2006). Subsequently, the simple random sampling technique can be applied within each stratum, offering a compromise between feasibility and capturing relevant variations within the ethnobotanical landscape.

In the field of ethnobotany, qualitative investigations exhibit distinct characteristics, including the frequent utilization of theoretical samples and various intentional sampling methods (Marshall, 1996). Qualitative studies often presume that certain cases yield more "enriched" insights compared to others, thus selecting such cases enhances the researcher's capacity to comprehend a specific scenario (Marshall, 1996). Many instances in ethnobotanical studies involve the use of small samples to facilitate more intricate insights, with the primary aim being a detailed exploration rather than generalization of findings (Marshall, 1996; Curtis et al., 2000).

Despite the unique attributes of qualitative research within ethnobotany, numerous scholars contend that this approach still warrants the assessment of sample quality. The selection of samples should align coherently with and explicitly address the research objectives at hand (Dixon-woods *et al.*, 2004; Curtis *et al.*, 2000).

3.5 Sampling Methods in Ethnobotanical Studies in Morocco

In a study conducted by Fakchich in 2021, during which they compiled and analyzed 63 ethnobotanical studies carried out in Morocco between 1991 and 2015, it was concluded that, for the collection of ethnobotanical data, 39 out of 63 studies did not declare the sampling methods used, accounting for a percentage of 61%. Additionally, 17 studies (26%) employed stratified probabilistic sampling, while 5 studies (7%) utilized random sampling. Lastly, two studies employed both random and stratified probabilistic sampling simultaneously (Fakchich *et al*, 2022; Fakchich J., 2021b; Fakchich and Elachouri, 2021a, 2014).

So, the issue of sampling has not been given priority in many ethnobotanical studies. This can be attributed to the fact that ethnobotany has its roots in the social sciences. However, due to the growing concern for making results reproducible and comparable on one hand, and for making inferences in ethnobotanical studies on the other, sampling has gradually become recognized as essential for ethnobotanical research in general and quantitative ethnobotany in particular (Houéhanou *et al.*, 2016).

4. Data Collection Methods

4.1 Methods of Collecting Ethnobotanical Data in Scientific Literature

In the realm of quantitative ethnobotany, the utilization of numbers and statistics might impress, yet their significance remains hollow without a foundation in reliable ethnographic data. Ethnobotanical research relies on a myriad of ethnographic methods, predominantly derived from the social sciences, to amass data that can be subjected to qualitative or quantitative analysis (Martin, 2014).

This chapter serves the purpose of delving into the extensively employed methods and techniques for extracting insights from informants or respondents, many of which trace their origins to the field of anthropology. In a comprehensive manner, we will elucidate these methodologies, highlighting both their merits and limitations.

Diverse strategies have been harnessed by researchers to capture the nuances of individual ethnobotanical knowledge. As ethnobotany operates within the realm of the social sciences, it seamlessly integrates techniques from this domain into the data collection process. The choice of a

particular method is intricately linked to the overarching objective of the study. The "Free Listing" technique entails requesting informants to compose a list of terms associated with a designated cultural domain (Quinlan, 2005). For instance, an inquiry such as "Which medicinal plants are utilized within the community?" prompts informants to enumerate all the plants they are acquainted with. Quinlan (2005) underscores that this method yields a substantial volume of valuable information and facilitates the identification of specialized domain experts. Nevertheless, it may have limitations in addressing more targeted inquiries. This technique serves as an initial step in ethnobotanical data collection, offering a broad overview of the cultural knowledge and practices related to plants. By tapping into informants' familiarity, it provides insights into the scope and depth of their understanding. However, it's important to recognize that while "Free Listing" captures a wealth of information, its open-ended nature may not be suited for probing specific details or addressing intricate queries (Franjieh *et al*., 2022; Kanter *et al*., 2020).

The guided tour technique involves embarking on a field excursion alongside a community member (or members) possessing specialized expertise in plant species identification. This collaborative approach serves the dual purpose of validating vernacular names assigned to inventoried plant species, a process often initiated through activities such as Free Listing or interviews (Albuquerque *et al*., 2014). Engaging in guided tours with proficient community members amplifies the accuracy and reliability of ethnobotanical data collection. This method not only corroborates the authenticity of gathered information but also enriches the comprehension of plant utilization practices. By directly associating vernacular names with actual plant specimens, the guided tour method establishes a bridge between traditional ecological knowledge and scientific botanical classification. It's noteworthy that the guided tour technique contributes to a more comprehensive documentation of plant-based practices within the community. By synergizing insights from techniques like Free Listing with the precise identifications facilitated by guided tours, researchers can craft a more nuanced portrayal of the cultural significance and ecological roles of distinct plant species.

Participant observation is a pertinent technique for delving into the intricacies of a community's realities by engaging with their daily experiences to glean essential information. In this method, the investigator is required to possess an adept understanding of their research domain and possess the capacity to chronologically recall lived or witnessed events (Bernard, 2006). Through participant observation, researchers become active participants within the community, enabling them to grasp the subtleties of daily life, social interactions, and cultural practices. This approach demands a heightened level of cultural sensitivity and immersion, fostering a holistic comprehension that extends beyond conventional data collection strategies. Participant observation yields a treasure trove of qualitative insights, unveiling intricate layers of contextually embedded information. It is worth noting that data derived from participant observation tend to be predominantly qualitative rather than quantitative. This is due to the technique's focus on capturing the qualitative dimensions of behaviors, rituals, and social dynamics within the community. While participant observation may not yield extensive quantitative data, its immersive nature empowers researchers to unearth profound layers of meaning and cultural significance. Emerson, Fretz, and Shaw (2011), (Emerson, Fretz and Shaw, 2011) further emphasize that meticulous and comprehensive fieldnotes are an integral component of participant observation. These detailed accounts provide a rich foundation for analysis and interpretation, allowing researchers to capture the essence of community life in its natural setting.

Group discussion is a data collection strategy that emphasizes interaction and discourse between an investigator and a group. This approach facilitates the extrapolation of information related to a well-defined study subject, evaluation of data collection methodologies, or solicitation of the group's

interpretation of observed phenomena during the study (Albuquerque *et al*., 2014). Various data collection techniques, such as Free Listing, Guided Tour, Participant Observation, or Group Discussion, are frequently synergized with interview methodologies to enhance data validation in ethnobotanical studies. Moreover, successful interviews necessitate a solid command of the research questions by the investigator (Albuquerque *et al*., 2014). This data collection approach fosters data encoding and categorization, lending itself to comprehensive statistical analysis. However, it's essential to recognize that interviewees may encounter limitations in their responses. In the realm of ethnobiology, diverse interview approaches are harnessed, encompassing structured (standardized), unstructured (non-standardized), semi-structured, and informal interviews. The incorporation of group discussions bears multiple advantages. By harnessing communal knowledge, it offers insights that might elude individual interviews. The dynamic interchange within a group setting illuminates diverse perspectives, thus enriching the understanding of intricate ethnobotanical knowledge systems.

- No-Standardized Interview: In this approach, the interviewer is guided solely by a list of topics. The interviews are unstructured and take the form of informal conversations. The non-standardized interview is regarded as an appropriate method for exploratory data collection, particularly in the context of discovery. This is the type of interview commonly employed in our investigations, especially when we have limited familiarity with the study region, and also due to our affiliation with an orally-based society.
- Standardized Interview: In contrast, the interviewer in a standardized interview follows a fixed and formalized questionnaire. The formulation and sequence of questions are determined by the questionnaire itself. The use of a fixed questionnaire restricts the scope of subjects that can be addressed and often yields little novel information (Thorsen and Tharp, 1989; Smith and Thomas, 2018).

The choice between standardized and non-standardized interviews hinges on the specific research goals and the nature of the study context. While standardized interviews offer a structured framework for data collection and facilitate comparability across responses, non-standardized interviews provide flexibility and room for in-depth exploration. In ethnobotanical research, the selection of the appropriate interview method must consider the cultural dynamics, local traditions, and the richness of oral knowledge transmission within the community.

Ethnobiological studies primarily employ interview techniques and formal structured questionnaires for data collection. In this regard, the reliability of data has been a subject of discussion among certain authors (Albuquerque et al., 2014) and is contingent upon the interviewer, the environment, and the duration of the interview. While some researchers have utilized cognitive methods such as "free lists" (Atran et al., 2002), others have employed "objective botanical tests" (Godoy *et al*., 1998), "transect surveys" (Zarger and Stepp, 2004), 2004), and specimen identification by informants (in the field, through vouchers, or images) (Begossi, 1996). Additionally, methods like "self-reports" have also been utilized (Ticktin and Johns, 2002). The choice of data collection methods in ethnobiology is contingent on the research objectives and the characteristics of the study context. While structured questionnaires offer standardized data, cognitive methods like "free lists" allow participants to freely contribute their knowledge. Meanwhile, techniques such as "transect surveys" facilitate systematic botanical observations in the field, contributing to a comprehensive understanding of plant diversity and utilization practices. The inclusion of "self-reports" provides insights into individuals' perspectives and experiences, enhancing the holistic comprehension of ethnobotanical knowledge.

Reyes García highlights that comparing results from various studies is challenging, as different methods *may* capture distinct dimensions of ethnobotanical knowledge that do not necessarily overlap. This implies that researchers should either select data collection methods to ensure they capture the desired dimension or incorporate a range of methods to attain a comprehensive understanding of individual ethnobotanical knowledge.

4.2 Methods of Collecting Ethnobotanical Data in Morocco

In Morocco, the interview technique proves to be the simplest and most suitable. Several other techniques are employed, albeit to a lesser extent due to their requirements. Among these techniques, we can mention, among others, Free Listing, Guide Tour, Participant Observation, and Group Discussion.

Indeed, within 2021 study conducted by Fakchich and Elachouri (Fakchich and Elachouri, 2021a), it was found that among the 63 compiled studies, questionnaires that had been prepared in advance were the primary method used to gather ethnobotanical information and facilitate participant observation. Out of these, 58 studies employed a combination of structured and semi-structured questionnaires, while two studies incorporated participant observation techniques (Rhaffari *et al.*, 2002). The structured questionnaire was meticulously designed to extract local plant names, diverse medicinal applications, specific plant parts utilized, and the techniques employed for preparing and administering treatments to patients. It is worth noting that three other studies did not explicitly detail the methodologies employed for the collection and compilation of ethnobotanical data.

Conclusion

Ethnobotany has evolved to encompass intricate relationships between plant diversity and culture. The selection of sampling and data collection methods is crucial to ensure the reliability of conclusions. Both quantitative and qualitative approaches are essential for exploring the connections between human communities and plants. The rarefaction curve is a key tool for assessing knowledge saturation. Ethnobotanical research in Morocco exemplifies the application of diverse data collection methods, including interviews and questionnaires. In summary, these methodologies shed light on human-plant relationships, and a well-crafted approach enhances the credibility of findings, contributing to a better understanding of this interdependence.

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