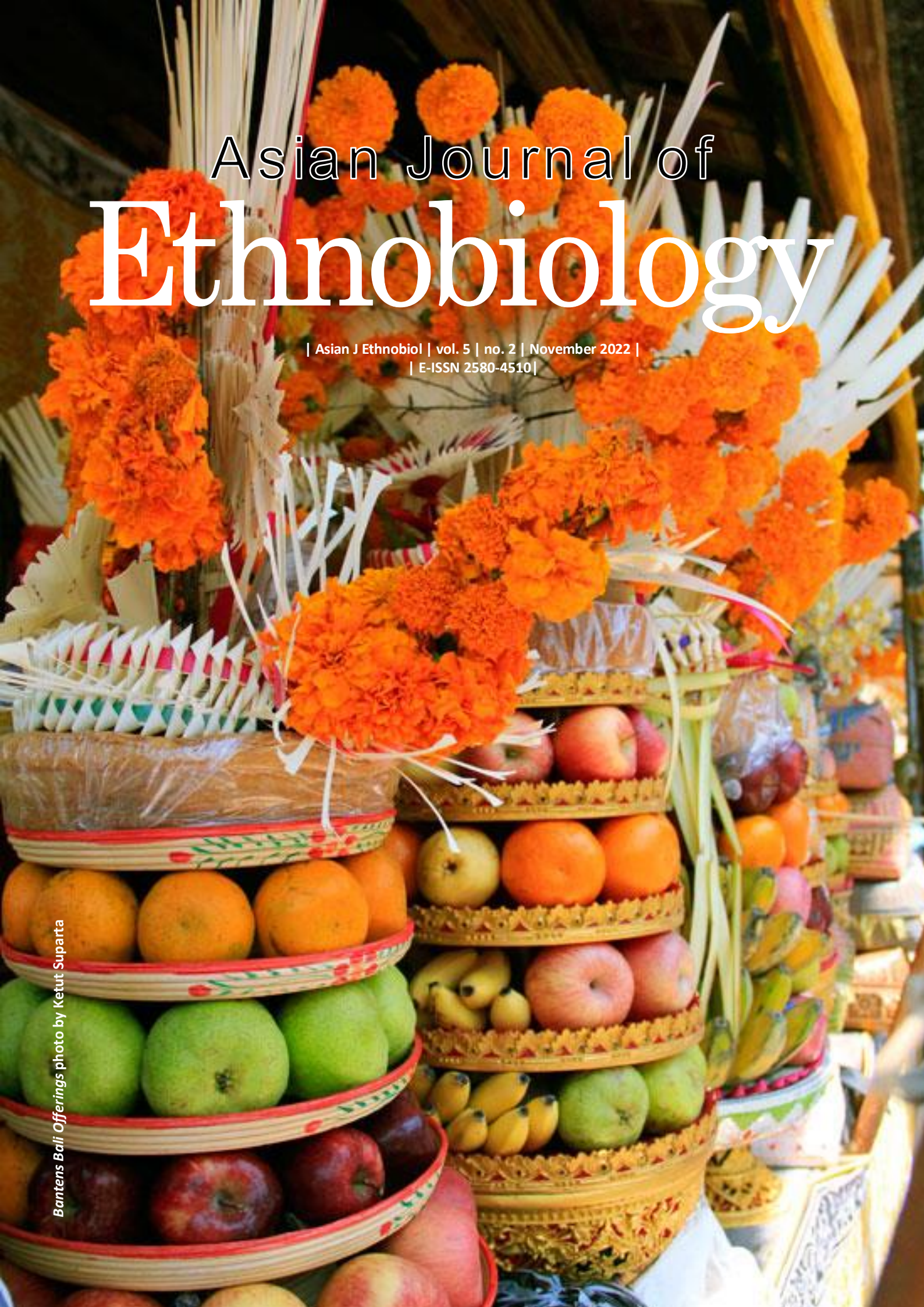
Asian Journal of Ethnobiology

| Asian J Ethnobiol | vol. 5 | no. 2 | November 2022 |
| E-ISSN 2580-4510|



Bantens Bali Offerings photo by Ketut Suparta

Asian Journal of Ethnobiology

| Asian J Ethnobiol | vol. 5 | no. 2 | November 2022 | E-ISSN 2580-4510 |

Published semiannually **PRINTED IN INDONESIA**

E-ISSN: 2580-4510

9 772580 451107

Asian Journal of Ethnobiology

| Asian J Ethnobiol | vol. 5 | no. 2 | November 2022 |

ONLINE
http://smujo.id/aje

e-ISSN
2580-4510

PUBLISHER
Society for Indonesian Biodiversity

CO-PUBLISHER
Universitas Padjadjaran, Sumedang, Indonesia

OFFICE ADDRESS
Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran. Jl. Raya Bandung-Sumedang Km 21, Jatinangor, Sumedang 45363, West Java, Indonesia. Tel. +62-22-7796412 line 104, Fax. +62-22-7794545, email: editors@smujo.id

PERIOD OF ISSUANCE
May, November

Society for Indonesian Biodiversity

Universitas Padjadjaran Sumedang, Indonesia

Published by Smujo International for The Society for Indonesian Biodiversity and Universitas Padjadjaran Sumedang, Indonesia

GUIDANCE FOR AUTHORS

Aims and Scope *Asian Journal of Ethnobiology* **(Asian J Ethnobiol)** encourages submission of manuscripts dealing with relationships between humans and their biological nature, including ethnobotany, ethnomycology, ethnozymology, ethnozoology, ethnoecology, traditional environmental/ ecological knowledge, ethnometereology, ethnoastronomy, ethnomedicine, ethnopharmacognosy, ethnoveterinary, ethnogastronomy, urban ethnobiology, linguistic ethnobiology, ethical and legal aspects of the biodiversity conservation and other related fields of study within anthropology and biology; as well as impact of economic activity on individuals in community and its social consequences.

Article types The journal seeks for: (i) **Research papers**, (ii) **Reviews**, and (iii) **Short communications**. Original full-length research manuscripts are limited to 8,000 words (including tables and figures) or proportional to articles in this publication number (beyond that, it should be with notice). Review articles are also limited to 8,000 words, while Short communications should be less than 2,500 words, except for pre-study (can be more).

Submission: The journal only accepts online submissions through the open journal system **(https://smujo.id/aje/about/submissions)** or, for login problems, email the editors at unsjournals@gmail.com (or editors@smujo.id). Submitted manuscripts should be the original works of the author(s). Please ensure that the manuscript is submitted using the template, which can be found at (https://biodiversitas.mipa.uns.ac.id/D/template.doc). The manuscript must be accompanied by a cover letter containing the article title, the first name and last name of all the authors, and a paragraph describing the claimed novelty of the findings versus current knowledge. Please also provide a list of five potential reviewers in your cover letter. They should come from outside your institution and better from three different countries. Submission of a manuscript implies the submitted work has not been published (except as part of a thesis or report, or abstract) and is not being considered for publication elsewhere. When a group writes a manuscript, all authors should read and approve the final version of the submitted manuscript and its revision; and agree on the submission of manuscripts for this journal. All authors should have made substantial contributions to the concept and design of the research, acquisition of the data and its analysis, drafting the manuscript, and correcting the revision. All authors must be responsible for the work's quality, accuracy, and ethics.

Ethics Author(s) must be obedient to the law and/or ethics in treating the object of research and pay attention to the legality of material sources and intellectual property rights.

Copyright If the manuscript is accepted for publication, the author(s) still hold the copyright and retain publishing rights without restrictions. For the new invention, authors must manage its patent before publication.

Open Access The journal is committed to free-open access that does not charge readers or their institutions for access. Readers are entitled to read, download, copy, distribute, print, search, or link to the full texts of articles, as long as not for commercial purposes. The license type is CC-BY-NC-SA.

Acceptance Only articles written in US English are accepted for publication. Manuscripts will be reviewed by editors and invited reviewers (double-blind review) according to their disciplines. Authors will generally be notified of acceptance, rejection, or need for revision within 1 to 2 months of receipt. Manuscripts will be rejected if the content does not align with the journal scope, does not meet the standard quality, is in an inappropriate format, or contains complicated grammar, dishonesty (i.e., plagiarism, duplicate publications, fabrication of data, citations manipulation, etc.), or ignoring correspondence in three months. The primary criteria for publication are scientific quality and significance. **Uncorrected proofs** will be sent to the corresponding author by system or email as .doc or .docx files for checking and correcting typographical errors. The corrected proofs should be returned in 7 days to avoid publication delays. The accepted papers will be published online in chronological order at any time but printed at the end of each month.

Free of charge This publication is dedicated entirely to the advancement of science and technology, therefore author(s) or author institution(s) are not subject to publication fees. **Reprint** Authors or other parties may freely download and distribute. However, a printed request will be charged. It may be purchased when ordering by sending back the uncorrected proofs by email.

Manuscript preparation Manuscript is typed on A4 (210x297 mm^2) paper size, in a single column, single space, 10-point (10 pt) Times New Roman font. The margin text is 3 cm from the top, 2 cm from the bottom, and 1.8 cm from the left and right. Smaller lettering sizes can be applied in presenting tables and figures (9 pt). Word processing program or additional software can be used; however, it must be PC compatible, use the template, and be Microsoft Word based (.doc or .rtf; not .docx). **Scientific names** of species (incl. subspecies, variety, etc.) should be written in italics, except in italicized sentences. Scientific names (genus, species, author) and cultivar or strain should be mentioned completely for the first time mentioning it in the body text, especially for taxonomic manuscripts. The genus name can be shortened after the first mention, except in early sentences, or where this may generate confusion; name of the author can be eliminated after the first mention. For example, *Rhizopus oryzae* L. UICC 524 can be written hereinafter as *R. oryzae* UICC 524. Using trivial names should be avoided. **Biochemical and chemical nomenclature** should follow the order of the IUPAC-IUB. For DNA sequences, it is better to use Courier New font. Standard chemical abbreviations can be applied for common and clear used, for example, completely written butilic hydroxyl toluene (BHT) to be BHT hereinafter. **Metric measurements** should use IS denominations, and other systems should use equivalent values with the denomination of IS mentioned first. A dot should not follow abbreviations like g, mg, mL, etc. Minus index (m^{-2}, L^{-1}, h^{-1}) suggested being used, except in things like "per-plant" or "per-plot." **Mathematical equations** can be written down in one column with text; in that case, they can be written separately. **Numbers** one to ten are written in words, except if it relates to measurement, while values above them are written in number, except in early sentences. The fraction should be expressed in decimal. In the text, it should be used "%" rather than "percent." Avoid expressing ideas with complicated sentences and verbiage/phrasing, and use efficient and effective sentences.

The title of the article should be written in compact, clear, and informative sentence, preferably not more than 20 words. Name of author(s) should be completely written, especially for the first and the last name. **Name and institution** address should also be completely written with street name and number (location), postal code, telephone number, facsimile number, and email address. We choose local names in Bahasa Indonesia for universities in Indonesia. The mention of "strata" program, should be avoided. Manuscript written by a group, author for correspondence along with address is required (marked with "♥"). **The title page** (first page) should include title of the article, full name(s), institution(s) and address(es) of the author(s); the corresponding authors detailed postage and e-mail addresses (P), and phone (O) and fax numbers (O).

Abstract A concise abstract is required (about 200 words). The abstract should be informative and state briefly the aim of the research, the principal results and major conclusions. An abstract is often presented separately from the article, thus it must be able to stand alone (completely self-explanatory). References should not be cited, but if essential, then cite the author(s) and year(s). Abbreviations should be avoided, but if essential, they must be defined at their first mention. **Keywords** are about five words, covering scientific and local name (if any), research themes, and special methods used; and sorted from A to Z. **Abbreviations** (if any): All important abbreviations must be defined at their first mention there. **Running title** is about five words.

Introduction is about 600 words, covering the aims of the research and provide an adequate background, avoiding a detailed literature survey or a summary of the results. **Materials and Methods** should emphasize on the procedures and data analysis. **Results and Discussion** should be written as a series of connecting sentences, however, for a manuscript with long discussion should be divided into subtitles. Thorough discussion represents the causal effect mainly explains why and how the results of the research were taken place, and do not only re-express the mentioned results in the form of sentences. **Concluding** sentence should be given at the end of the discussion. **Acknowledgements** are expressed in a brief; all sources of institutional, private and corporate financial support for the work must be fully acknowledged, and any potential conflicts of interest are noted.

Figures and Tables of a maximum of three pages should be clearly presented. The title of a picture is written down below the picture, while the title of a table is written above the table. Colored figures can only be accepted if the information in the manuscript can lose without those images; the chart is preferred to use black and white images. The author could consign any picture or photo for the front cover, although it does not print in the manuscript. All images property of others should be mentioned the source. Author is suggested referring to Wikipedia for international boundaries and Google Earth for satellite imagery. If not specifically mentioned, it is assumed to refer to these sources. **There is no appendix**, all data or data analysis is incorporated into Results and Discussions. For broad data, it can be displayed on the website as a supplement.

References Preferably 80% of it comes from scientific journals published in the last 10 years. In the text, give the author names followed by the year of publication and arrange from oldest to newest and from A to Z; in citing an article written by two authors, both of them should be mentioned; however, for three and more authors only the first author is mentioned followed by et al. For example, Saharjo and Nurhayati (2006) or (Boonkerd 2003a, b, c; Sugiyarto 2004; El-Bana and Nijs 2005; Balagadde et al. 2008; Webb et al. 2008). Extent citation should be avoided, as shown with the word "cit." Reference to unpublished data and personal communication should not appear in the list but should be cited in the text only (e.g., Rifai MA 2007, pers. com. (personal communication); Setyawan AD 2007, unpublished data). In the reference list, the references should be listed in alphabetical order. Names of journals should be abbreviated. Always use the standard abbreviation of a journal's name according to the **ISSN List of Title Word Abbreviations** (www.issn.org/2-22661-LTWA-online.php). Please include DOI links for journal papers. The following examples are for guidance.

Journal:

Saharjo BH, Nurhayati AD. 2006. Domination and composition structure change at hemic peat natural regeneration following burning; a case study in Pelalawan, Riau Province. Biodiversitas 7: 154-158. DOI: 10.13057/biodiv/d070213.

The usage of "et al." in long author lists will also be accepted:

Smith J, Jones M Jr, Houghton L et al. 1999. Future of health insurance. N Engl J Med 965: 325-329. DOI: 10.10007/s002149800025.

Book:

Rai MK, Carpinella C. 2006. Naturally Occurring Bioactive Compounds. Elsevier, Amsterdam.

Chapter in the book:

Webb CO, Cannon CH, Davies SJ. 2008. Ecological organization, biogeography, and the phylogenetic structure of rainforest tree communities. In: Carson W, Schnitzer S (eds.). Tropical Forest Community Ecology. Wiley-Blackwell, New York.

Abstract:

Assaeed AM. 2007. Seed production and dispersal of *Rhazya stricta*. 50th annual symposium of the International Association for Vegetation Science, Swansea, UK, 23-27 July 2007.

Proceeding:

Alikodra HS. 2000. Biodiversity for development of local autonomous government. In: Setyawan AD, Sutarno (eds.). Toward Mount Lawu National Park; Proceeding of National Seminary and Workshop on Biodiversity Conservation to Protect and Save Germplasm in Java Island. Universitas Sebelas Maret, Surakarta, 17-20 July 2000. [Indonesian]

Thesis, Dissertation:

Sugiyarto. 2004. Soil Macro-invertebrates Diversity and Inter-Cropping Plants Productivity in Agroforestry System based on Sengon. [Dissertation]. Universitas Brawijaya, Malang. [Indonesian]

Information from the internet:

Balagadde FK, Song H, Ozaki J, Collins CH, Barnet M, Arnold FH, Quake SR, You L. 2008. A synthetic *Escherichia coli* predator-prey ecosystem. Mol Syst Biol 4: 187. DOI: 10.1038/msb.2008.24. www.molecularsystembiology.com.

THIS PAGE INTENTIONALLY LEFT BLANK

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 5, Number 2, November 2022
Pages: 71-83

E-ISSN: 2580-4510
DOI: 10.13057/asianjethnobiol/y050201

Traditional knowledge of medicinal plants used in Ile-Ife, Southwestern Nigeria

YUSUF OLA MUKAILA[1], OLANIRAN TEMITOPE OLADIPO[1], OLUWABUNMI OKERINMOLA AROGUNDADE[1], ABDULWAKEEL AYOKUN-NUN AJAO[2,♥]

[1]Department of Botany, Obafemi Awolowo University. Ile-Ife 220005, Nigeria
[2]Department of Botany and Plant Biotechnology, University of Johannesburg. P.O. Box 524, Auckland Park 2006, Johannesburg, South Africa.
Tel.: +27-11-559-4555, ♥email: ajwak880@gmail.com

Manuscript received: 23 May 2022. Revision accepted: 19 July 2022.

Abstract. *Mukaila YO, Oladipo OT, Arogundade OO, Ajao AA-N. 2022. Traditional knowledge of medicinal plants used in Ile-Ife, Southwestern Nigeria. Asian J Ethnobiol 5: 71-83.* The invaluable importance of traditional herbal medicine has necessitated systematic documentation of medicinal knowledge. This study documented medicinal plants used by the inhabitants of Ile-Ife. Ethnobotanical data were collected through semi-structured interviews with 70 informants. The interview focused on the local names of the plants, medicinal uses, plant parts used, where the plants are sourced, and methods of preparation. The data collected were analyzed and compared with previous studies using quantitative indices. The conservation statuses of the recorded plants were retrieved from IUCN online database. Eighty-seven (87) medicinal plants from 43 families were implicated to be used in Ile-Ife from our survey. Euphorbiaceae was the most implicated family with eight species; herbs (36%) were the dominant plant habit, and the leaf (46%) was the most frequently used plant part. The informants preferred decoction (37%) as the method of preparation. Over 50% of the plants were collected from the wild. The conservation status of the 26 implicated plants in this study has been accessed, 17 plants fall under the least concern (LC) category, while five species are vulnerable (VU). The study highlights the need to intensify studies on the conservation of medicinal plants and also provides baseline data for future pharmacological and phytochemical studies while preserving the cultural medicinal practices of Ile-Ife.

Keywords: Conservation, ethnobotany, Ile-Ife, indigenous knowledge, medicinal plants

INTRODUCTION

Nigeria is a developing country with many rural areas where orthodox medicines are not available or not accessible; traditional medicine is, therefore, the first line of defense for many ailments such as coughs, fevers, headaches, psychosis, etc. Traditional medicine has been reported to be of unquantifiable importance to locals around the world (Van Wyk et al. 2008), but as important as these traditional medicines are, there have been several scientific reports of their side effects (Ekor 2013), which led to the prescription of standardization of herbal medicines by the World Health Organization (WHO 2002). The standardization process consists of several steps, the first of which is the systematic documentation of the medicinal plants and their uses in rural communities around the world.

The importance of documentation of medicinal plants of the world cannot be overemphasized as several reports have confirmed that traditional medicinal knowledge is usually passed down orally and may soon be lost if documentation efforts are not intensified (Van Wyk et al. 2008; Erinoso and Aworinde 2018; Az-Zahra et al. 2021). Furthermore, the preservation and documentation of indigenous uses of plants were also pronounced as one of the cogent priorities for strategic action in plant science at the 19th International Botanical Conference in Shenzhen, China (Crane et al. 2017). Before and after this pronouncement, there have been several efforts towards documentation of medicinal plants of the world, but it was reported that Nigeria does not have a national herbal pharmacopeia because very few ethnobotanical studies have been undertaken in Nigeria, a problem associated with a lack of funding and expertise in the field (Erinoso and Aworinde 2018).

Ile-Ife is a well-known cultural site in Nigeria and beyond. It is a general belief that Ile-Ife is the ancestral home of the Yoruba people in the southwestern part of Nigeria. The use of herbal medicine in Ile-Ife was reported to be very popular among its residents, owing to the cultural status of the town among the Yorubas (Omisore et al. 2009). Unfortunately, there is no record of in-depth ethnobotanical research in Ile-Ife until now. This research, therefore, aims to document the medicinal plants of Ile-Ife and their corresponding uses. This will serve as baseline data for future phytochemical and pharmacological studies and also preserve the medicinal cultural practices of Ile-Ife. Over-exploitation has been reported as a threat to the medicinal plants of the world (Naguib 2011). The conservation statuses of the recorded medicinal plants were surveyed in this study to unravel whether the use of plants for medicinal purpose in Ile-Ife pose a challenge in terms of extinction risk to the diversity and abundance of the plants in the area.

MATERIALS AND METHODS

Study area

The study was carried out in Ile-Ife, a part of the Yoruba-speaking area of southwestern Nigeria, politically designated as the Ife Central Local Government Area of Osun State (Figure 1). Geographically, Ile-Ife is located in the tropical savannah climate zone of West Africa between latitude 7º28'N and 7º45'N and longitude 4º30'N and 4º34'E (Ajala and Olayiwola 2013). Ile-Ife is considered to have the richest cultural heritage in southwestern Nigeria (Omisore et al. 2009). It is made up of rural settlements with agriculture being the prevalent occupation. The annual average temperature is 26.2ºC, the average rainfall is between 1000-1250 mm, and the average humidity is 75-100% (Ajala and Olayiwola 2013).

Informants sampling

A reconnaissance survey of the study area led to the identification and selection of 70 informants known among the people of Ile-Ife as having substantial knowledge of medicinal plants. They consist mainly of traditional healers and herb sellers, while some were elderly people known to know medicinal plants.

Data collection and quantitative analysis

The survey was carried out between November 2018 and September 2019 using semi-structured interviews as described by Martin (1995), and the interviews were conducted in the local language so that informants could properly express themselves. Before the start of the interview, informants were informed about the scope of the research to gain their confidence. Interviews were conducted individually while there were two separate group interviews. With the help of four informants on separate field walks and a trained taxonomist, all plants mentioned were collected and identified. Voucher specimens were prepared and deposited at the Obafemi Awolowo University Herbarium (IFE). The global conservation status of all the plants mentioned was then surveyed using the IUCN online database (2020).

Frequency Index (Madikizela et al. 2012) was used to identify the most cited plant. It was calculated as follows:

$$FI = \frac{Frequency\ of\ citation}{Total\ number\ of\ informants\ (70)} \times 100\%$$

Diversity of uses and its evenness were calculated with the Shannon-Wiener index as described by Begossi (1996) using the following equations:

$$Diversity\ of\ uses\ (H') = -\sum[Pi \times \ln Pi]$$
$$Evenness = H' \div Hmax$$

Where Pi is the number of individual citations per species and Hmax was calculated as the natural logarithm of the total number of informants.

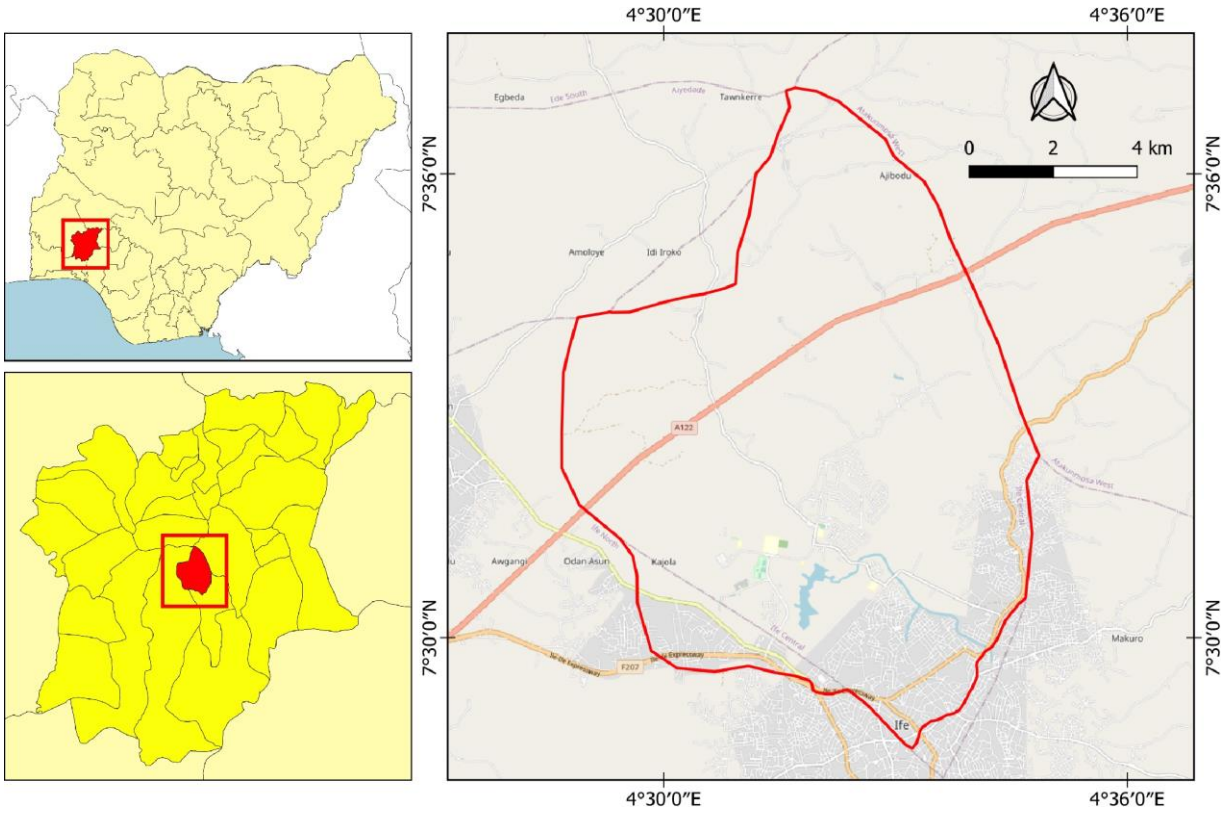


Figure 1. A map of the study area in Ile-Ife, Southwestern Nigeria

Informant Consensus Factor (ICF) (Trotter and Logan 1986) was calculated to assess the agreement on the therapeutic efficacy of plants in each disease category.

$$FIC = \frac{Nur - Nt}{Nur - 1}$$

Where N_{ur}= Number of use record for a particular disease category, and N_t= Total number of plants mentioned by all informants for the disease category.

Rahman Similarity Index (RSI) (Rahman et al. 2019) was used to compare the result of the study with other studies from the region.

$$RSI\ (\%) = \frac{d}{a + b + c - d} \times 100\%$$

Where a= number of species unique to the present study, b= number of species unique to the cited study, c= number of species common to both studies and d= common species used to treat similar ailments.

Ethical approval

The study was approved by the Postgraduate Committee of Obafemi Awolowo University, Ile-Ife. Informants were aware of the planned use of information and consent was given that the information could be published. Each participant was also compensated accordingly. The ethical principles of data collection concerning traditional resource rights as stated in the latest edition of the International Society of Ethnobiology (2006) were followed.

RESULTS AND DISCUSSION

Informants

The 70 informants consist of 39 men and 31 women residing within the community, all of whom were above the age of 30. Most of the informants (52.9%) attained the primary level of education, while 34.3% had no formal education. Twenty-seven of the informants were herbalists, while 19 herb-sellers were interviewed and seven of them claimed to be unskilled staff of the Obafemi Awolowo University, Ile-Ife (Table 1).

Medicinal plants of Ile-Ife

The 70 informants reported 87 medicinal uses of plants for various illnesses. The 87 plants belonging to 43 families. The plants' families, botanical names, authorities, vernacular names, habits, plant parts used, and method of preparation appear in Table 2. This is an indication that traditional medicine is still well practiced in the research area, as similar studies from other parts of the country recorded lower numbers of plant species. For example, Kayode et al. (2008) reported 44 species from Ilesa, which is a neighboring community; Alade and Ajibesin (2017) reported 36 species from Ijaw; Idu et al. (2014) reported 63 species from Idoma, while Ampitan (2013) reported 27 plant species from Biu, with a RSI of 7.92, 15.38, 9.40, and 4.00 respectively. The low index of the study from Biu (4.00) is because it is a location in the northern part of the country with different climatic conditions and floristic composition.

Regarding the number of medicinal plants, Euphorbiaceae is represented with the highest number of species (8), followed by Fabaceae and Malvaceae (6 species each), Asteraceae and Cucurbitaceae (5 species each), and Poaceae (4 species), while 27 species are the sole representatives of their families. This is consistent with the results of a previous study in Keffi (Mowobi et al. 2016), where Euphorbiaceae was the most represented family. Even though plants from the families Fabaceae and Asteraceae are usually the most cited in ethnobotanical surveys (Ajao et al. 2019, Farooq et al. 2019), there have been several reports of the presence of varieties of metabolites and phytochemicals of medicinal importance in many plants of the family Euphorbiaceae (Mwine and Van Damme 2011), which could account for their superior abundance in this study.

Telfairia occidentalis Hook. F. in the family Cucurbitaceae has the highest frequency index as the most mentioned plant. This may be related to the fact that the plant, in addition to being used as medicine, is a widely eaten vegetable in the study area. The value for the index of diversity of uses of the recorded plants is 4.24 with an evenness of 0.99. This shows a relatively high diversity of use when compared to sites with known high biodiversity like Brazil and Thailand, with an index of 4.80 and 4.97, respectively (Begossi 1996). Also, the evenness is higher than those of both sites.

Table 1. Demographic characteristics of informants

Characteristics	Frequency	Percentage
Sex		
Male	39	55.7
Female	31	44.3
Age (years)		
31-40	14	20.0
41-50	31	44.3
51-60	19	27.1
Greater than 60	6	8.6
Education level		
None	24	34.3
Adult education	3	4.3
Primary level	37	52.9
Secondary level	6	8.6
Occupation		
Farmers	6	8.6
Herbalists	27	38.6
Herb-sellers	19	27.1
Driver	3	4.3
Trader	8	11.4
Unskilled university staff	7	10.0

Ailments treated with the medicinal plants

The reported medicinal plants were used to treat several ailments. It was observed in some cases that the physical properties of plant extracts were related to the ailments they are used to treat. For example, the majority of the herbal remedies used as blood tonics have a characteristic red or blood-like colour after preparation, while some informants mentioned that the diabetes ailment is caused by the consumption of excess sugar and could be cured with any plant that has a bitter taste. This phenomenon was reported in the previous literature (Cotton 1996) and referred to as 'the doctrine of signature, which is widely accepted.

Another noteworthy field experience was the underlining spirituality of some of the remedies. For example, some informants stressed that plants are not to be collected at night because the plants will be "sleeping" and therefore impotent or inactive for their purpose if collected then. This is true when viewed from the physiological angle, as plants do not photosynthesize at night. Also, in the treatment of gonorrhea with the decoction of the fruits of *Citrullus colocynthis* (L.) Schrader, *Ananas comosus* (L.) Merr., *Citrus aurantifolia* (Christm.) Swingle, *Xylopia aethiopica* (Dunal.) A. Rich, and potash. The plant materials must be arranged in the pot accordingly, starting with *C. colocynthis*, and water from the pot must not pour out of it while cooking, else, the preparation loses its potency. This spiritual aspect of herbal remedies is called Shamanism (Cotton 1996).

The ailments were grouped into categories according to the WHO international classification of ailments (WHO 1987). The result revealed the highest number of plants (34) used for Urinary and Reproductive Diseases (URD), followed by fevers (F) and skin diseases (SD), treated with 26 plants each, while there were no plants in the eye-ear infection category (Figure 2). The abundance of the URD plants is linked to the fact that most diseases in the category infect the majority of the people in the age bracket of the informants. Inadequate toilet facilities and polygamy may have also played a vital role in spreading the diseases in this category. Fevers have been reported to account for over 39% of deaths in Nigeria (Muhammad et al. 2017). Figure 2 also contains the results of the Informant Consensus Factor (ICF) for each ailment category. The ICF values range between 0.95 for the URD category and 1.00 for the Mouth-Throat Infections (MTI), Cancer (C), and Hair Problems (HP) categories since they only have one cited plant. These values are high compared to other studies (Faruque et al. 2018; Farooq et al. 2019), which indicates that medicinal knowledge is being shared within the study area.

Habits of the medicinal plants

An analysis of the growth forms of the recorded medicinal plants revealed that herbs were the most represented with 31 species, followed by trees with 29 species. Climbers and shrubs were represented with 17 and 10 species, respectively. Other studies have reported the abundance of herbs as the most used in herbal medicines (Mahwasane et al. 2013; Teklehaymanot 2009). The prevalence of the herbaceous life form was attributed to easing of collection (Ajao et al. 2019), while that of the tree is because they are obtainable in all seasons (Tariq et al. 2017).

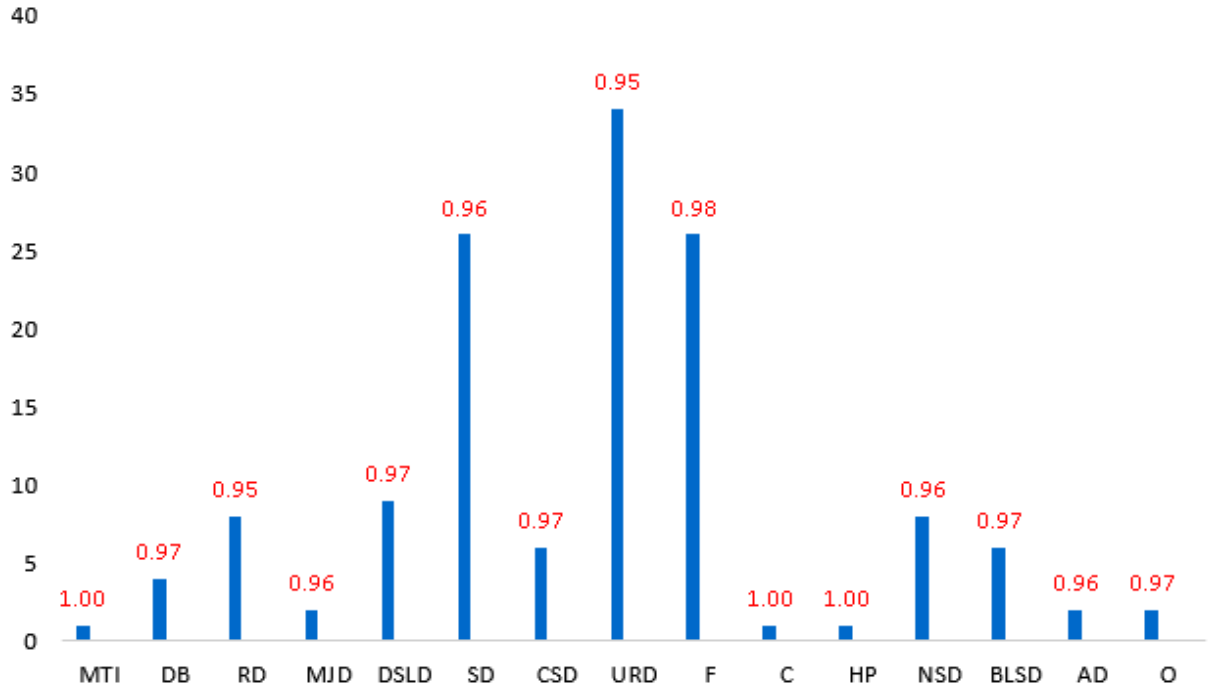


Figure 2. The number of plants used for each disease category and their corresponding ICF values. Note: MTI mouth-throat infections; DB, diabetes; RD, respiratory disorders; MJD, Muscular and Joint disorders; DSLD, digestive system and Liver diseases; SD, skin diseases; CSD, circulatory system diseases; URD, urinary and reproductive diseases; F, fever; C, cancer; HP, hair problems; NSD, nervous system disorders; BLSD , blood and lymphatic system diseases; AD, antidote; O, others

Table 2. List of medicinal plants and their conservation status

Scientific name	Family	Vernacular (Yoruba) name	Source	Voucher specimen number	Plant habit	Plant part used	Mode of use	Conservation status	Frequency index (%)
Amaranthus spinosus L.	Amaranthaceae	*Tete elegun*	Wild	IFE17849	Herb	Leaf	A mixture of the leaf paste and local soap is used to bath children having teething problem	NA	9
Crinum jagus (Thompson) Dandy	Amaryllidaceae	*Ogede odo, isu merii*	Cultivated wild	IFE17895	Herb Climber	Bulb	1. Juice from the heated bulb is mixed with honey and used for convulsion 2. Water decoction of the bulb and *Xylopia aethiopica* is used to treat convulsion	NA	47
Anacardium occidentale L.	Anacardiaceae	*Kashu*	Cultivated wild	IFE17908	Tree	Seed	Water decoction of the seed is used for diseases related to high blood pressure	NA	12
Mangifera indica L.	Anacardiaceae	*Mongoro*	Cultivated Wild	IFE17874	Tree	Leaf, Stem bark	Decoction of the leaf and stem bark in fermented maize water is used to treat chronic malaria	DD	90
Spondias purpurea L.	Anacardiaceae	*Iyeye*	Wild	IFE17879	Tree	Fruit, stem bark	1. Powder of the dried fruits and *Xylopia aethiopica* is mixed with palm kernel oil to treat dandruff 2. Water decoction of the stem bark and potash is used to treat fibroid	LC	33
Xylopia aethiopica (Dunal.) A. Rich	Annonaceae	*Eru alamo, Eru awonka*	Wild	IFE17825	Tree	Fruit	1. Water decoction of the fruit is used for gonorrhea 2. Powdered fruit is mixed with Sulphur and added to body cream to treat skin diseases	LC	79
Alstonia boonei De Willd.	Apocynaceae	*Ahun*	Wild	IFE17914	Tree	Stem bark	1. Water decoction of the bark is used for malaria 2. Infusion of the stem bark in palm wine is used to treat malaria 3. Infusion of the stem bark in local gin is rubbed on the body to treat measles	VU	69
Calotropis procera (Aiton) W.T.Aiton	Apocynaceae	*Bomubomu*	Cultivated	IFE17912	Shrub	Leaf, latex	1. The latex is applied topically for boil 2. Leaf is macerated in water and used to treat measles 3. The latex is used to treat toothache	NA	76
Rauvolfia vomitoria Afzel.	Apocynaceae	*Asofeyeje, Oloora*	Wild	IFE17897	Shrub	Leaf, stem bark, root	1. Infusion of stem bark in alcohol is used to treat pile and backache 2. Decoction of leaf and root is used to treat yellow fever 3. Powdered dry root is swallowed with water to treat insomnia	LC	73
Anchomanes difformis (Blume) Engl.	Araceae	*Isu ogirisako*	Wild	IFE17899	Herb	Tuber	The tuber is cut, infused in water, and taken to treat stroke	LC	10
Caladium bicolor (Aiton) Vent.	Araceae	*Eje jesu*	Wild	IFE17832	Herb	Leaf	Leaf is macerated in fermented maize water to treat stomach ulcers	NA	16
Elaeis guineensis Jacq.	Arecaceae	*Ope-eyin*	Cultivated Wild	IFE17913	Tree	Root	Decoction of the root and potash is used to treat hernia	LC	19

Ageratum conyzoides (L.) L.	Asteraceae	*Imi-esu, Apasa, Rerin-komi*	Wild	IFE17827	Herb	Leaf whole plant	1. Leaf juice is applied to the minor wounds to stop bleeding 2. Decoction of the whole plant is used to bath baby to prevent measles 3. Maceration of the leaves in fruit juice of *Citrus aurantifolia* is used to treat female infertility	LC	70
Bidens pilosa L.	Asteraceae	*Molaganran*	Wild	IFE17926	Herb	Leaf	Decoction of leaf is used to treat rheumatism	NA	17
Chromolaena odorata (L.) R. King & H. Rob.	Asteraceae	*Akintola*	Wild	IFE17882	Herb	Leaf	1. Leaf maceration is used for diarrhea 2. Leaf maceration is used for malaria	NA	81
Melanthera scandens (Schumach. & Thonn.) Roberty	Asteraceae	*Ako yunrun*	Wild	IFE17845	Herb	Leaf	Leaf maceration is used for diarrhea	NA	23
Vernonia amygdalina Del.	Asteraceae	*Ewuro*	Cultivated	IFE17880	Herb	Leaf	1. Leaf maceration is used for diabetes 2. Leaf juice is mixed with palm oil and drunk to treat measles 3. Leaf is squeezed and stuffed in the nostrils to control epistasis	NA	91
Kigelia africana (Lam.) Benth.	Bignoniaceae	*Pandoro*	Wild	IFE17864	Tree	Fruit, root	1. Decoction of the fruits is used for convulsion 2. Infusion of fruit in salty water is used for dizziness 3. Dried root is ground and mixed with palm oil to treat dizziness 4. Infusion of root in palm wine is used to treat yellow fever	LC	50
Newbouldia laevis Seem.	Bignoniaceae	*Akoko*	Wild	IFE17907	Shrub	Leaf	1. Decoction of stem bark is used for hypertension 2. Decoction of the leaves with the fruits of *Citrus aurantifolia* is used to treat yellow fever 3. Leaf is macerated with water and taken orally to stop menstruation after pregnancy	NA	57
Bixa orellana L.	Bixaceae	*Ewe aje*	Wild	IFE17883	Shrub	Leaf	1. Leaf juice is used for eczema 2. Decoction of the leaf with fruits of *Citrus aurantifolia* and fermented maize water is used to treat malaria	NA	47
Ananas comosus (L.) Merr.	Bromeliaceae	*Ope oyinbo*	Cultivated	IFE17894	Herb	Fruit	1. Decoction of fruit is taken for gonorrhea 2. Decoction of unripe fruit is used to ease difficult labor	NA	47
Carica papaya L.	Caricaceae	*Ibepe*	Cultivated Wild	IFE17858	Tree	Leaf, fruit, root	1. Coldwater infusion of the fruits is used for malaria 2. Decoction of unripe fruit is used to ease difficult labor 3. Decoction of the root and the root of *Parkia biglobosa* (Jacq.) R.Br. ex G.Don. is used to treat malaria	VU	87

Garcinia kola Heckel	Clusiaceae	*Orogbo*	Cultivated wild	IFE17851	Tree	Fruit, root	1. Fruits are chewed for cough 2. Decoction of the root and stem bark is used for cough	VU	77
Cnestis ferruginea Vahl ex DC	Connaraceae	*Akara aje*	Wild	IFE17829	Tree	Fruit	Fruits are chewed to paste and then applied to snakebite wounds	NA	6
Kalanchoe pinnata (Lam.) Pers.	Crassulaceae	*Abamoda*	Wild	IFE17909	Herb	Leaf	Decoction of leaf with salty water is used to treat cough	NA	3
Lagenaria breviflora (Benth.) Roberty	Cucurbitaceae	*Taagiri*	Wild	IFE17893	Climber	Fruit	Decoction of the fruit and the leaves of *Newbouldia laevis* is used to treat measles	NA	20
Citrullus colocynthis (L.) Schrader	Cucurbitaceae	*Bara*	Cultivated wild	IFE17850	Climber	Leaf, pod, fruit	1. Leaves are macerated in local gin and drunk for gonorrhea 2. Decoction of the fruit, fruits of *Ananas comosus*, *Citrus aurantifolia*, *Xylopia aethiopica,* and potash is taken to treat gonorrhea	NA	54
Luffa cylindrica (L.) M. Roem	Cucurbitaceae	*Kankan ayaba*	Wild	IFE17898	Climber	Fruit	Fresh fruits are heated then squeezed to produce juice which is topically applied to stretch marks	NA	41
Momordica charantia L.	Cucurbitaceae	*Ejinrin wewe, igbole aja*	Wild	IFE17843	Climber	Leaf	1. Leaf is macerated in water to treat pile and also used as aphrodisiac 2. Leaf is macerated in salty water and used for syphilis	NA	69
Telfairia occidentalis Hook. F.	Cucurbitaceae	*Apiroko*	Cultivated	IFE17902	Climber	Leaf	Maceration of leaf with malt drinks is drunk to improve blood level	NA	99
Euphorbia lateriflora Schum. & Thonn.	Euphorbiaceae	*Enu opiri*	Wild	IFE17896	Herb	Leaf, latex	1. The latex is applied to whitlow 2. Leaf is macerated and used to bath to treat skin diseases	NA	20
Alchornea cordifolia Mull Arg.	Euphorbiaceae	*Isin*	Wild	IFE17846	Shrub	Fruit	Fruits are chewed to treat cough	LC	4
Euphorbia hirta L.	Euphorbiaceae	*Kannajogbe*	Wild	IFE17870	Herb	Whole plant	Whole plant juice is applied to a fresh wound, especially cuts	NA	4
Jatropha curcas L.	Euphorbiaceae	*Botuje, Lapalapa funfun*	Shrub	IFE17900	Shrub	Leaf	1. Leaf is macerated in saltwater and drunk for dysentery 2. Leaf is macerated and mixed with local chalk and taken orally to prevent miscarriage	LC	50
Jatropha gossypiifolia L.	Euphorbiaceae	*Botuje, lapalapa pupa*	Cultivated	IFE17890	Shrub	Leaf	1. Leaf is macerated in water to treat gonorrhea 2. Leaf is macerated in water and drunk to prevent difficult labor	NA	56
Jatropha multifida L.	Euphorbiaceae	*Ogege*	Cultivated wild	IFE17891	Shrub	Leaf stalk	Leaf stalk is used to wash tongue in cases of coated tongue	NA	13
Abrus precatorius L.	Fabaceae	*Omisinmisin*	Wild	IFE17887	Climber	Leaf	The leaves are chewed to treat cough	NA	33
Mucuna pruriens (L.) DC.	Fabaceae	*Yerepe*	Wild	IFE17873	Climber	Leaf	1. Leaf maceration is used as a blood supplement 2. Leaf maceration is used to treat measles	NA	66

Senna alata (L.) Roxb.	Fabaceae	*Asunran, ajaawa*	Cultivated wild	IFE17836	Shrub	Leaf, flower	1. Young leaves are macerated in water, mixed with salt, and used for skin diseases 2. Leaves are powdered, mixed with Sulphur, alum, and any cream to treat skin diseases 3. Leaves are macerated in water, potash is added and drunk for pile 4. Inflorescence is dried and powdered with potash to treat female infertility	LC	62
Senna hirsuta (L.) Irwin & Barneby	Fabaceae	*Rere*	Wild	IFE17889	Herb	Leaf	Leaf is pounded and added to the fruit juice of *Citrus aurantifolia* to treat typhoid	NA	24
Senna siamea Lam.	Fabaceae	*Kasia*	Cultivated wild	IFE17911	Tree	Leaf, stem bark	Decoction of leaf and bark is used for malaria	LC	41
Tetrapleura tetraptera (Schum & Thonn (Taub.)	Fabaceae	*Aidan*	Cultivated wild	IFE17841	Tree	Leaf, seed	1. Leaf is macerated and alum is added to treat cough 2. Dried seeds are powdered and mixed with cold pap to treat stroke	LC	37
Anthocleista djalonensis A. Chev.	Gentianaceae	*Sapo*	Wild	IFE17885	Tree	Stem bark, root	1. Decoction of the stem bark is used to treat malaria 2. Decoction of the root with the leaves of *Phyllanthus amarus* is used to treat pile	LC	61
Heliotropium indicum L.	Heliotropiaceae	*Ogbe-ori-akuko*	Wild	IFE17835	Herb	Leaf	Decoction of the leaf is taken to treat skin diseases	NA	26
Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill.	Irvingaceae	*Ooro*	Cultivated wild	IFE17888	Tree	Leaf	Leaf is macerated with leaf of *Hibiscus* spp to treat gonorrhea	VU	26
Ocimum gratissimum L.	Lamiaceae	*Foromoba*	Cultivated	IFE17840	Herb	Leaf	1. Leaf juice is applied to a fresh wound 2. Leaves are macerated in water and drunk to treat malaria	NA	89
Persea americana Mill.	Lauraceae	*Pia-nla*	Cultivated wild	IFE17877	Tree	Leaf	1. Decoction of the leaf is taken to treat stroke 2. Decoction of the leaf is used to treat high blood pressure	LC	49
Allium sativum L.	Liliaceae	*Ayuu*	Cultivated wild	IFE17853	Herb	Bulb	1. Infusion of the bulb in alcohol is used to treat pile 2. The bulbs are eaten to treat stomach ulcer 3. Infusion of the bulbs in fruit juice of *Cirus aurantifolia* is used to treat hypertension	NA	79
Corchorus olitorus L.	Malvaceae	*Ewedu*	Cultivated	IFE17905	Herb	Leaf	1. Leaves are cooked without salt to treat measles 2. Leaves are macerated in cold water and drunk during difficult labor	NA	49
Gossypium hirsutum L.	Malvaceae	*Owu*	Cultivated wild	IFE17844	Shrub	Leaf	1. Decoction of leaf is used for malaria 2. Decoction of the leaf and leaf of *Citrus aurantifolia* is used as a blood tonic	VU	79

Hibiscus spp	Malvaceae	*Afaimoni-konimora*	Wild	IFE17855	Herb	Leaf	The leaves are macerated together with the leaves of *Ageratum conyzoides* and *Irvingia gabonensis* and taken to treat gonorrhea	NA	7
Sida acuta Burm. F.	Malvaceae	*Osepotu*	Wild	IFE17868	Herb	Leaf	The leaves are macerated in local gin and drunk to treat syphilis	NA	7
Sida veronicifolia Lam.	Malvaceae	*Eesi ile*	Wild	IFE17928	Herb	Leaf	Leaf is macerated in water and drunk to treat pile	NA	7
Theobroma cacao L.	Malvaceae	*Kokoo*	Cultivated wild	IFE17826	Shrub	Leaf	Decoction of the leaf and seeds of *Sorghum bicolor* (L.) Moench is used as a blood tonic	NA	36
Azadirachta indica A. Juss.	Meliaceae	*Dogoyaro*	Cultivated wild	IFE17839	Tree	Leaf	Decoction of the leaf and the leaf of *Cymbopogon citratus* is taken to treat malaria	LC	70
Entandrophragma angolense D.C.	Meliaceae	*Ijebo*	Wild	IFE17859	Tree	Leaf	Decoction of the bark is used to treat malaria	VU	19
Khaya grandifoliola C. DC.	Meliaceae	*Oganwo*	Wild	IFE17852	Tree	Leaf, stem bark	1. Decoction of the leaf and stem bark is used for rheumatism 2. Decoction of the stem bark is used to treat yellow fever 3. Decoction of the stem bark is used to treat malaria 4. Infusion of the stem bark in water is taken to treat skin diseases	VU	77
Sphenocentrum jollyanum Pierr.	Menispermaceae	*Akerejupon*	Wild	IFE17867	Shrub	Root, stem bark	1. Dried root is powdered and mixed with pap to treat typhoid 2. Stem bark is dried, powdered, and taken with pap to treat stomachache	NA	59
Triclisia subcordata Oliv.	Menispermaceae	*Kanranjongbon*	Wild	IFE17830	Climber	Root	The powdered dry root is mixed with black soap and used to wash the breast in cases of breast cancer	NA	7
Ficus exasperata Vahl.	Moraceae	*Eepin*	Wild	IFE17837	Tree	Leaf, latex	1. Decoction of the leaf is used to treat high blood pressure 2. Leaves are macerated, and potash is added and taken for syphilis 3. Leaves are macerated with the leaves of *Vernonia amygdalina* and used as an aphrodisiac 4. The latex is mixed with palm oil and sugar to treat cough	LC	55
Artocarpus altilis (Parkinson) Fosberg	Moraceae	*Gbere, berefurutu*	Cultivated wild	IFE17915	Tree	Root, stem bark	Decoction of root and stem bark is used for dizziness	NA	11
Ficus sur Forrsk.	Moraceae	*Opoto*	Wild	IFE17831	Tree	Leaf	Leaf is macerated in water and drunk to cleanse the blood	NA	1
Moringa oleifera Lam.	Moringaceae	*Ewe igbale*	Cultivated wild	IFE17910	Tree	Root, stem bark	1. Decoction of the root, fruits of *Citrus aurantifolia*, and potash is used to treat syphilis 2. The dried stem bark is powdered with local chalk, mixed with local gin, and used as first aid for any ailment	NA	36

Musa paradisiaca L.	Musaceae	*Ogede agbagba*	Cultivated wild	IFE17892	Herb	Fruit, stem	1. Unripe fruit is cooked and eaten for diabetes 2. Decoction of the stem and leaves of *Ficus exasperata* is used to treat hypertension	NA	41
Pycnanthus angolensis (Welw.) War.	Myristicaeae	*Akomu*	Wild	IFE17906	Tree	Leaf, stem bark	1. Latex from the stem is used to treat cough 2. Decoction of the leaf and stem bark is used to treat insomnia and hypertension	NA	37
Argemone mexicana L.	Papaveraceae	*Egele*	Cultivated wild	IFE17925	Herb	Leaf	1. Leaves are macerated in water and used to bath and drunk for measles 2. Decoction of the leaf in fermented maize water is used to treat yellow fever	NA	9
Parquetina nigrescens (Afzel.) Bullock	Periplocaceae	*Ogbo*	Wild	IFE17824	Climber	Leaf	Maceration of leaf is mixed with milk to improve blood level	NA	41
Bridelia ferruginea Benth	Phyllanthaceae	*Ira*	Wild	IFE17828	Tree	Stem bark	The dried bark is ground and mixed with the fruit juice of *Citrus aurantifolia* to treat typhoid	NA	20
Phyllanthus amarus Schum. & Thonn.	Phyllanthaceae	*eyin-olobe*	Wild	IFE17822	Herb	Whole plant	1. Decoction of the whole plant is used for fever 2. The whole plant is infused in the fruit juice of *Citrus aurantifolia* and used as an aphrodisiac and to treat backache	NA	50
Peperomia pellucida (L.) H.B & K.	Piperaceae	*Rinrin, irinrin*	Wild	IFE17865	Herb	Leaf	Leaf juice is applied to boil	NA	37
Plumbago zeylannica L.	Plumbaginaceae	*Inabiri*	Wild	IFE17843	Herb	Root	The root is powdered with *Mondia whitei* (Hook. F.) Skeels and mixed with food and used as an aphrodisiac	NA	13
Bambusa vulgaris Schrad. ex J.C. Wendl.	Poaceae	*Oparun*	Wild	IFE17869	Shrub	Leaf	1. Decoction of the leaf is used for hypertension 2. Decoction of the leaf and fruits of *Citrus aurantifolia* is used to treat malaria	NA	69
Cymbopogon citratus (D.C) Stapf.	Poaceae	*Kooko oba, ewe tii*	Cultivated	IFE17847	Herb	Leaf	Decoction of the leaf and fruits and the leaves of *Citrus aurantifolia* is used to treat malaria and yellow fever	NA	43
Saccharum officinarum L.	Poaceae	*Ireke*	Cultivated	IFE17884	Herb	Leaf, stem	Decoction of the leaf and stem is used to treat malaria	NA	11
Zea mays L.	Poaceae	*Agbado*	Cultivated	IFE17848	Herb	Flower	Decoction of the inflorescence is used for measles	LC	16
Securidaca longipedunculata Fresen.	Polygalaceae	*Ipeta*	Wild	IFE17857	Tree	Root	The dried root is powdered with seeds of *Aframomum melegueta* K. Schum. and swallowed for diabetes	NA	17
Morinda lucida Benth	Rubiaceae	*Oruwo*	Cultivated wild	IFE17860	Tree	Leaf, stem	1. The leaf is macerated in water to treat diabetes 2. Decoction of the leaf and stem bark is used for malaria	NA	60
Nauclea latifolia Sm.	Rubiaceae	*Egbesi*	Wild	IFE17875	Tree	Leaf, stem bark, root	1. Decoction of the stem bark is drunk to treat malaria 2. Decoction of the leaf, root, and stem bark is used to treat insanity 3. Decoction of the leaf is used to treat pile	NA	44

Plukenetia conophora Mull Arg.	Rubiaceae	*Awusa*	Wild	IFE17875	Climber	Fruit	Decoction of the fruits and the cooked fruits are used to treat snakebites	NA	16
Citrus aurantifolia (Christm.) Swingle	Rutaceae	*Orombo, osan wewe*	Cultivated wild	IFE17823	Shrub	Fruit	1. Decoction of the fruit is taken for gonorrhea 2. Fruits are infused in water to treat malaria 3. Juice from the fruit is used to treat indigestion, stomachache, and vomiting	NA	94
Citrus sinensis L.	Rutaceae	*Osan mimu*	Cultivated wild	IFE17904	Shrub	Leaf, stem bark	Decoction of the leaves and stem bark is used to treat malaria	NA	81
Lecaniodiscus cupanioides Planch. ex Benth.	Sapindaceae	*aka, akika*	Wild	IFE17842	Tree	Root	Decoction of the root is taken for menstrual pains	NA	11
Hannoa undulata Guill &Perr.	Simaroubaceae	*Orijin*	Cultivated wild	IFE17871	Tree	Leaf	The leaf juice is rubbed on the affected area to treat skin disease	NA	40
Solanum dasyphyllum Schum & Thonn.	Solanaceae	*Mafowokan omo mi, igbagun,*	Cultivated wild	IFE17886	Shrub	Leaf	The leaf is powdered with the seeds of *Xylopia aethiopica*, mixed with local soap, and used to bath for measles	NA	27
Solanum verbascifolium L.	Solanaceae	*Yewuru*	Wild	IFE17881	Shrub	Leaf	The leaf is macerated in fruit juice of *Citrus aurantifolia* and used to treat female infertility	NA	24
Laportea aestuans (L.) Chew	Urticaceae	*Olojongbodu, lapotia*	Wild	IFE17866	Herb	Leaf	The leaf is powdered and mixed with shea butter and rubbed on the affected area to treat skin diseases	NA	30
Aframomum melegueta K. Schum.	Zingiberaceae	*Ataare*	Wild	IFE17862	Herb	Seed	The powdered seeds are mixed with palm oil to treat stomachache	DD	30

Note: NA: Not available; LC: Least concern; DD: Deficient data; EN: Endangered

Plant parts used

The most used plant part was the leaf. This was reportedly used in 55 remedies, way beyond the stem bark (19 remedies), root, and fruits (14 remedies each). This corresponds with the results of a previous study (Keter and Mutiso 2012), where leaves were the most used plant part, followed by the stem bark, and root. Several other studies have also reported leaves as the most used plant part (Farooq et al. 2019; Natcha et al. 2019). Other plant parts used include seeds, flowers, latex, leaf stalk, pod, tuber, bulb, and sometimes the whole plant. Even though the informants gave no particular reason for choosing a part of a plant, the use of leaves in herbal medicine is mainly due to easy accessibility (Farooq et al. 2019) and not because they are more effective than other parts of the plant (Aruwa et al. 2020). Also, the use of leaves has been said to assist conservation efforts because leaves easily regenerate compared to parts like stem bark or roots, which may kill the plant (Kayode et al. 2008).

Method of preparation

The methods of preparation reported in this study include leaf paste, juicing, decoction, infusion, powdering, direct application, maceration, chewing, pounding, and cooking. Among these, the decoction was the most prevalent method of preparation, recommended 56 times. This was followed by maceration, recommended 37 times, and powdering 17 times. Apart from infusion (14) and juicing (11), the rest of the methods of preparation had less than 10 recommendations each (Table 2). The decoction was reported to be the overwhelmingly favored method of preparation (Keter and Mutiso 2012), even though available scientific information does not support decoction as the best method of preparation for herbal medicine (Ajao et al. 2019). The majority of the remedies (80.7%) are prepared using only a single plant or in combination with some non-plant materials, while some of the remedies include the combination of two or more plants (polyherbal) and, in some cases, with non-plant materials. Non-plant materials recorded include honey, sulfur, salt, potash, and local chalk.

Conservation of the medicinal plants

Forty-nine of the recorded 87 medicinal plants are sourced by the informants from the wild. Informants are aware of the importance of medicinal plants but do not realize the possibility of extinction due to overexploitation and lack of conservation of these plants. The scarcity of any plant is not attributed to over-exploitation but to unfavorable seasons and the expansion of human settlement. Because of this, the IUCN online database was used to survey the conservation status of these plants. The results revealed information for only 26 of the recorded species, highlighting the lack of conservation information for most species. Of the 26 species, 17 have a conservation status of LC (Least Concern), which confirms a sufficiently stable global population for the species. Two species (*Aframomum melegueta* K.Schum. and *Mangifera indica* L.) have a DD (Deficient Data) status as there was not sufficient data to determine their conservation status, even though the plants in this category are strongly thought to have a conservation status of vulnerable (VU) (Isichei 2010). Seven species (*Alstonia boonei* de Wild., *Carica papaya* L., *Entandrophragma angolense* (Welw.) C.DC., *Garcinia kola* Heckel, *Gossypium hirsutum* L., *Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill., and *Khaya grandifoliola* C.DC.) have a VU status, meaning they are likely to become endangered if steps are not taken to conserve them, and there are no species in the EN (Endangered) category. Even though these are global conservation statuses, the results are an overall combination of the individual local exploitation of the flora of the world. Studies on the conservation of vulnerable species are therefore encouraged, while it is also important to assess the conservation status of the medicinal plants that have not been assessed.

In contributing to the conservation of the cultural practices in Ile-Ife and providing background data for phytochemical and pharmacological studies, the study identifies 87 plants from 43 families used in the traditional herbal system of Ile-Ife and their corresponding uses. Euphorbiaceae is the most represented family, with eight species. Most of the remedies were monoherbal, while some were polyherbal. In addition, some non-plant materials were used in combination therapy, which included salt, sulphur, honey, and local chalk. The leaf was the most used plant part, while decoction was the preferred preparation method. The highest number of plants was used for the URD category, and the doctrine of signature was observed in some of the remedies, while other remedies have spiritual advice attached to them. However, a survey of the conservation status of medicinal plants revealed very little information as there was no conservation information for over 70% of the plants. Research into the conservation status of these plants is therefore recommended, in addition to studies to confirm the folkloric usages of the documented plants.

ACKNOWLEDGEMENTS

The authors appreciate G.A. Ademoriyo of the Department of Botany, Obafemi Awolowo University, Ile-Ife. We also appreciate the local informants for sharing their knowledge of medicinal plants and authorizing the publication of the same, without them this study would have been impossible. Dr. A.A. Ajao also appreciates the ongoing support of Prof. Annah Moteetee of the Department of Botany and Plant Biotechnology, University of Johannesburg, South Africa.

REFERENCES

Ajala OA, Olayiwola AM. 2013. An assessment of the growth of Ile-Ife, Osun State Nigeria, using multi-temporal imageries. J Geogr Geol 5 (2): 43-49. DOI: 10.5539/jgg.v5n2p43.

Ajao AA, Sibiya, NP, Moteetee AN. 2019. Sexual proess from nature: A systematic review of medicinal plants used as aphrodisiacs and sexual dysfunction in Sub-Saharan Africa. South Afr J Bot 122: 342-359. DOI: 10.1016/j.sajb.2018.08.011.

Alade GO, Ajibesin K. 2017. Herbal medicine: Clerics' knowledge in a sub urban center in Niger Delta, Nigeria-a plot study. J Pharm Pharmacogn Res 5 (4): 200-216.

Ampitan TA. 2013. Ethnobotanical survey of medicinal plants in Biu local government area of Borno state, Nigeria. Comprehensive J Herbs Med Plants 2 (1): 7-11.

Aruwa CE, Mukaila YO, Ajao AA, Sabiu S. 2020. An appraisal of antidotes' effectiveness: Evidence of the use of phyto-antidotes and biotechnological advancement. Molecules 25: 1516. DOI: 10.3390/molecules25071516.

Az-Zahra FR, Sari NLW, Saputry R, Nugroho GD, Sunarto, Pribadi T, Setyawan AD.2021. Review: Traditional knowledge of the Dayak Tribe (Borneo) in the use of medicinal plants. Biodiversitas 22: 4633-4647. DOI: 10.13057/biodiv/d221057.

Begossi A. 1996. Use of ecological methods in ethnobotany: Diversity indices. Econ Bot 50 (3): 280-289. DOI: 10.1007/BF02907333.

Cotton CM. 1996. Ethnobotany: Principles and Applications. British Library Catalouging in Publication Data, New York.

Crane PR, Ge S, Hong D-Y, Huang H-W, Jiao G-L, Knapp S, Kress WJ, Mooney H, Raven PH, Wen J, Wu W-H, Yang H-M, Zhu W-H, Zhu Y-Z. 2017. The Shenzhen Declaration on Plant Sciences. XIX International Botanical Conferennce, Shenzhen, China. http://www.ibc2017.cn/Declaration/ (accessed 11/02/2020).

Ekor M. 2013. The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. Front Pharmacol 4: 177-182. DOI: 10.3389/fphar.2013.00177.

Erinoso SM, Aworinde DO. 2018. Current outlook and future promise of ethnobotany in Nigeria: A review and personal observation. Afr J Plant Sci 12 (4): 73-80. DOI: 10.5897/AJPS2017.1571.

Farooq A, Muhammad SA, Khalid A, Muhammad A, Muhammad U, Arshad MA. 2019. Ethno-medicinal knowledge of the rural communities of Dhirkot, Azad Jammu and Kashmir, Pakistan. J Ethnobiol Ethnomed 15: 45-52. DOI: 10.1186/s13002-019-0323-2.

Faruque MO, Uddin SB, Barlow JW, Hu S, Dong S, Cai Q, Li X, Hu X. 2018. Quantitative ethnobotany of medicinal plants used by indigenous communities in the Bandarban District of Bangladesh. Front Pharmacol 9: 40. DOI: 10.3389/fphar.2018.00040.

Idu M, Joseph OE, Oghale OU. 2014. Ethnomedicinal plants used by the Idoma people – Benue State, Nigeria. Amer J Ethnomed 1 (1): 72-88.

International Society of Ethnobiology. 2006. International society of ethnobiology code of ethics (with 2008 additions). http://ethnobiology.net/code-of-ethics/ (accessed 21/7/2021).

International Union for Conservation of Nature (IUCN). 2020. Online database. www.iucnredlist.org (Accessed 19/01/2020).

Isichei AO. 2010. Endangered plants in Nigeria: Time for a new paradigm for vegetation conservation. Nigerian Field (1 & 2): 64-84.

Kayode JL, Aleshinloye L, Ige OE. 2008. Ethnomedicinal use of plant species in Ijesa Land of Osun State, Nigeria. Ethnobot Leaflets 12: 164-170.

Keter LK, Mutiso PC. 2012. Ethnobotanical studies of medicinal plants used by traditional health practitioners in the management of diabetes in Lower Eastern Province, Kenya. J Ethnopharmacol 139: 74-80. DOI: 10.1016/j.jep.2011.10.014.

Madikizela B, Ndhlala AR, Finnie JF, VanStaden J. 2012. Ethnopharmacological study of plants from Pondoland used against diarrhea. J Ethnopharmacol 141: 61-71. DOI: 10.1016/j.jep.2012.01.053.

Mahwasane ST, Middleton L, Boaduo N. 2013. An ethnobotanical survey of indigenous knowledge on medicinal plants used by the traditional healers of the Lwamondo area, Limpopo Province, South Africa. South Afr J Bot 88: 69-75. DOI: 10.1016/j.sajb.2013.05.004.

Martin GJ. 1995. Ethnobotany: A Methods Manual. Chapman and Hall, London. DOI: 10.1007/978-1-4615-2496-0.

Mowobi GG, Abubakar S, Osuji C, Etim VN, Ogechi N, Egya JJ. 2016. Ethnobotanical survey of medicinal plants used for the treatment of skin disease in Keffi, Nigeria. Amer J Phytomed Clin Ther 4 (2): 73-90.

Muhammad F, Abdulkareem JH, Chowdhury AA. 2017. Major public health problems in Nigeria: A review. South East Asia J Pub Health 7 (1): 6-11. DOI: 10.3329/seajph.v7i1.34672.

Mwine JT, Van Damme P. 2011. Why do Euphorbiaceae tick as medicinal plants? A review of Euphorbiaceae family and its medicinal features. J Med Plants Res 5: 652-662.

Naguib NYM. 2011. Organic vs chemical fertilization of medicinal plants: A concise review. Adv Environ Biol 5 (2): 394-400.

Natcha S, Prasit W, Henrik B, Angkhana I. 2019. Traditional uses of Leguminosae among the Karen in Thailand. Plants 8: 600. DOI: 10.3390/plants8120600.

Omisore EO, Ikpo IJ, Oseghale GE. 2009. Maintenance survey of cultural practices in Ile-Ife. Nigerian J Build Appraisals 4 (4): 255-268. DOI: 10.1057/jba.2009.3.

Rahman IU, Hart R, Afzal AL, Iqbal ZI, Ijaz F, Abd-Allah EF, Ali N, Khan SM, Alqarawi AA, Alsubeie M, Bussmann RW. 2019. A new ethnobiological similarity index for the evaluation of novel use reports. Appl Ecol Environ Res 17 (2): 2765-2777. DOI: 10.15666/aeer/1702_27652777.

Tariq A, Sadia S, Pan K, Ullah I, Mussarat S, Sun F, Abiodun OO, Batbaatar A, Li Z, Song D, Xiong Q, Ullah R, Khan S, Basnet BB, Kumar B, Islam R, Adnan M. 2017. A systematic review on ethnomedicines of anti-cancer plants. Phytother Res 31: 202-224. DOI: 10.1002/ptr.5751.

Teklehaymanot T. 2009. Ethnobotanical study of knowledge and medicinal plants use by the people in Dek Island in Ethiopia. J Ethnopharmacol 124: 69-78. DOI: 10.1016/j.jep.2009.04.005.

Trotter RT, Logan MH. 1986. Informant consensus: a new approach for identifying potentially effective medicinal plants. In Plants in Indigenous Medicine and Diet: Bio-Behavioral Approaches. Redgrave Publishing Company, New York.

Van Wyk B-E, De Wet H, Van Heerden FR. 2008. An ethnobotanical survey of medicinal plants in the southeastern Karoo, South Africa. South Afr J Bot 74: 696-704. DOI: 10.1016/j.sajb.2008.05.001.

World Health Organization (WHO). 2002. Traditional medicine strategy, World Health Organization, Geneva, 2002, WHO/EDM/TRM/2002.1.

World Health Organization. 1987. International classification of primary health care, Second edition (ICPC-2), 1987. http://www.whoint/classifications/icd/adaptations/icpc2/en/ (accessed 22/01/2020).

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 5, Number 2, November 2022
Pages: 84-91

E-ISSN: 2580-4510
DOI: 10.13057/asianjethnobiol/y050202

Zootherapeutic animals used by Awi, Gamo, and Konta communities in Amhara and Southern Regions of Ethiopia

YIHEW BIRU♥, AMARE GIBRU, ZELALEM TEMESGEN, KEBEBEW HUNDE, TESFU FEKENSA
Wild Animals Case Team, Animal Biodiversity Directorate, Ethiopian Biodiversity Institute (EBI). P.O. Box 30726, Addis Ababa, Ethiopia.
Tel.: +251-911-022665, ♥email: asse.biru@gmail.com

Manuscript received: 8 March 2022. Revision accepted: 20 July 2022.

Abstract. *Biru Y, Gibru A, Temesgen Z, Hunde K, Fekensa T. 2022. Zootherapeutic animals used by Awi, Gamo, and Konta communities in Amhara and Southern Regions of Ethiopia. Asian J Ethnobiol 5: 84-91.* The use of animals and animal products in traditional medicine is less explored than that of plant-based medication. And hence, this pilot study is aimed to assess the role of zootherapeutic animals in traditional medicine among Awi, Gamo, and Konta communities, Ethiopia. Data were collected from December 2020 to March 2021 using a semi-structured questionnaire, focus group discussions, and field observations. A total of 90 informants and 37 group discussants were included in the study. We calculated the use value (UV) and relative frequency of citation (RFC) of animals used in traditional medicine. A binary Logistic Regression model using SAS (9.0) was used to identify the major factors that affected respondents' knowledge about the importance of animal-based traditional medicine. Overall, we documented 20 medicinal animals having ethnozoological importance in treating nearly 23 human diseases. Out of the 20 vertebrate species used, mammals comprised 70%, followed by birds, 20%. Among the recorded animal species, hyena, porcupine, and bushbuck were commonly reported medicinal animals in the study areas. Meat, skin, and blood were the most frequently used animal products by local communities, with a pooled RFC of 0.48, 0.28, and 0.13, respectively. Asthma, protection from the evil eye, and broken bone were most commonly treated diseases using animal-based therapeutics. The binary logistic regression model revealed that age ($\chi 2$=10.53; *df*=3; P=0.01) and region ($\chi 2$=5.11; *df*=1; P=0.02) of respondents significantly affected ethnozoological knowledge of respondents. This study confirmed that the sampled communities have rich ethnozoological knowledge concerning the use of traditional medicine. Therefore, further in-depth studies involving traditional healers are recommended to clearly understand the role of wild animals in traditional medicine and design conservation options for the threatened medicinal animals.

Keywords: Ethnozoology, human diseases, traditional healers, traditional medicine, wild animals

INTRODUCTION

Despite the advance in modern medication, traditional medicine (TM) is still being used by various communities throughout the world (Alves 2012; Albuquerque et al. 2013). Communities, especially in rural areas in different continents, use TM to ensure their primary health care (d'Avigdor et al. 2014). In most African countries, TM has been linked to people and animal health for centuries and has been evolving across generations (Caudell et al. 2017). In Ethiopia, for example, TM is a common practice in the health care system of the communities, which has a strong relationship with the enormous diversity of animal and plant genetic resources, accompanied by the higher cultural diversity of the country (Getachew et al. 2002; Elias et al. 2013). However, most of the TM is obtained from medicinal plants (MPs) (Kefalew et al. 2015). Although plants and plant derivatives have been used as a major constituent of TM, the use of animals for medicinal purposes is reported to be crucial in the management of human health (Mishra et al. 2011; Borah and Prasad 2017; Mardiastuti et al. 2021). Thus, animals and animal products such as fur, bone, meat, blood, milk, egg, and skin have been documented as medicinal substances in various cultures and remain the backbone of TM (Alves et al. 2011; Alves and Alves 2011; Altaf et al. 2015; del Valle et al. 2015; Hernandez et al. 2015).

Several types of research have been conducted on the zootherapeutic activities of animals and their products to treat various human ailments throughout the world (Alves and Alves 2011; Mishra et al. 2011; Hernandez et al. 2015). Concerning the role of wild animals in the TM, both invertebrate and vertebrate species are used by traditional healers to prepare animal-based remedies across different societies (Alves et al. 2007; Alves and Alves 2011; Mussarat et al. 2021). However, in most scientific publications vertebrate species are more dominantly reported in the TM than invertebrate species (Alves and Alves 2011; Souto et al. 2011; Mulugeta et al. 2021). Particularly, the use of mammals and birds in the TM is well elaborated than the other animal taxa (Vijayakumar et al. 2015; Kendie et al. 2018; Zarazua-Carbajal et al. 2020; Manaye et al. 2021; Mussarat et al. 2021). For instance, a total of 44 animal species were used to treat more than 40 diseases among communities around Gibbon Wildlife Sanctuary, Assam, India (Borah and Prasad 2017). In Argentina, seven animal species were used to treat 22 ailments among mestizo communities (Hernandez et al. 2015). Likewise, a study by Altaf et al. (2015) reported the use of 108 animal species having zootherapeutic importance in Pakistan.

Although Ethiopia is characterized by high biodiversity and heterogeneous habitat types with intact cultural traditions by different ethnic groups, very few ethnozoological studies have been conducted (Tsegazeabe 2012; Dereje and Chane 2014; Kendie et al. 2018; Manaye et al. 2021). For instance, twenty-three animal species were reported to treat about 45 diseases in Degu'a Tembien, Tigray people (Tsegazeabe 2012). Another study in Amaro Woreda, Southern Ethiopia, documented 21 animal species to prepare remedies for 46 ailments among Kore people (Dereje and Chane 2014). A study in Northwestern Ethiopia also identified 51 animal species to treat around 36 diseases among the indigenous people in Metema Woreda (Kendie et al. 2018). A study in West Gojjam Zone, Amhara Region, Ethiopia, also reported using 33 medicinal animals to treat 26 human and livestock health problems (Manaye et al. 2021). A most recent study by Mulugeta et al. (2021) recorded the use of 20 animal species to treat about 30 different diseases in Arba Minch Zuria District Gamo Zone, Ethiopia. These few findings in Ethiopia revealed the enormous potential of animal-based TM among communities across the country.

The differences in the species used, type of diseases to cure, and preparation method imply that animal-based medicine is unique to an indigenous community, suggesting that context-specific study is necessary to add information of such knowledge of different regions in Ethiopia. Awi and Gamo zones, as well as Konta Special Woreda, have a great level of biodiversity across a variety of habitat types and strong traditional culture (Getaneh et al. 2019; Gochera et al. 2020). However, despite the great diversity of ethnic groups and cultures in these areas, ethnozoological studies of traditional medicinal animals have not yet been well addressed. The rich faunal resources, ethnic and cultural diversity in the areas call for an investigation and documenting animal-based TM used to treat different human ailments. Therefore, this study aimed to assess zootherapeutic animals used in TM among Awi, Gamo, and Konta communities in the Amhara and Southern Regions of Ethiopia.

MATERIALS AND METHODS

Study period and areas

The study was conducted between December 2020 to April 2021 in two zones (Awi and Gamo) and Konta Special Woreda (district). We used a multi-stage purposive sampling method to select the sampled areas. First, Zone and Woreda (an administrative division in Ethiopia managed by a local government) were purposively selected with the help of zonal and woreda wildlife authorities based on their wildlife potential and their experience in using animal-based traditional medicine. Accordingly, the Awi Zone from Amhara Region whereas, Gamo zone, and Konta Special Woreda from Southern Nations, Nationalities, and People's Region (SNNPR) was selected for the study (Figure 1).

The Awi zone is one of the administrative units in the Amhara Region, located at the coordinates 10°52′ to 11°3′ N latitude and 36°38′ to 37°8′ E longitude. The zone has a distance of 445 Km from Addis Ababa capital city of Ethiopia, and about 110 Km from Bahir Dar, the regional capital. The selected woreda in the Awi Zone, Guangua and Zigem, are found 57 and 140 km, respectively, from Injibara town, which is the administrative city of the zone, while Banja is located about 20 km radius south of Injibara. The administrative center of the Gamo zone is Arba Minch, located about 500 km south of Addis Ababa. The study districts Bonke and Chencha are located 60 and 42 km from Arba Minch town, respectively. In contrast, Konta Special Woreda is found in SNNPR, located between 6°30' N and 7°25' N, and 36°15' E and 36°55' E at a distance of 330 km from Hawassa, the capital of SNNPR (Bekalo et al. 2009). The Konta Special Woreda, besides its cultural diversities, has diversified wildlife and ecosystems with an enormous ecotourism potential.

Data collection procedure

Ethnozoological data were collected using several methods, namely, interviews using a questionnaire, focus group discussions (FGDs), and direct field observations. The participants were approached and informed of the study objectives in each woreda, and those who were willing to participate in the study were recruited for the study. A total of 90 general informants (36 female and 54 male) with 15 informants per woreda were selected in different age classes for the questionnaire survey (Table 1). Moreover, 37 (23 male and 14 female) individuals were purposively selected for FGDs. One FGD was held in each study woreda, and the size of group discussants varied from 5 to 7 individuals. The people from whom the data was collected comprise old-age community members, randomly selected respondents, spiritual intellectuals, and natural resource experts. The interview and FGDs were held in respective local languages with the help of native development agents at each study site.

Open-ended questions on wildlife potential of the area, trends in wildlife population across time, community views regarding the importance of wild animals, whether they have a role in TM, common human diseases treated based on zootherapeutic animals, threats to and conservation of these medicinal animals were all discussed during the FGDs. In addition, semi-structured interviews were employed to obtain information on a list of zootherapeutic animals, their reported importance(s), involving method(s) of preparation, routes of administration, and animal parts used. Moreover, a field guide to mammals and birds of the horn of Africa was displayed for respondents to confirm the local names of animals with corresponding pictures.

Data analysis

The commonly cited animal species and their parts for TM were analyzed using relative frequency of citation (RFC) and use value (UV). The RFC is the number of informants who reported medicinal uses of each species, and its value was calculated using the formula:

$$RFC = FC/N$$

Where; FC is the number of informants mentioning the use of the species and N is the number of informants participating in the survey (Mootsamy and Mahomoodly 2014). The use value (UV) is used to prove the relative importance of species. UV of a species is calculated using the equation:

$$UV = \Sigma U/n$$

Where; UV is the use value of a species, U refers to the number of uses mentioned by the informants for a given species, and n is the number of informants (Phillips and Gentry 1993).

To predict the important factors that affect respondents' knowledge in using wild animals for TM, we used Binary Logistic Regression Model in SAS 9.0. Potential factors, such as gender (GE), region of respondents (RE), age class (AGC), and educational status (ED), were used to develop the binary logistic regression model.

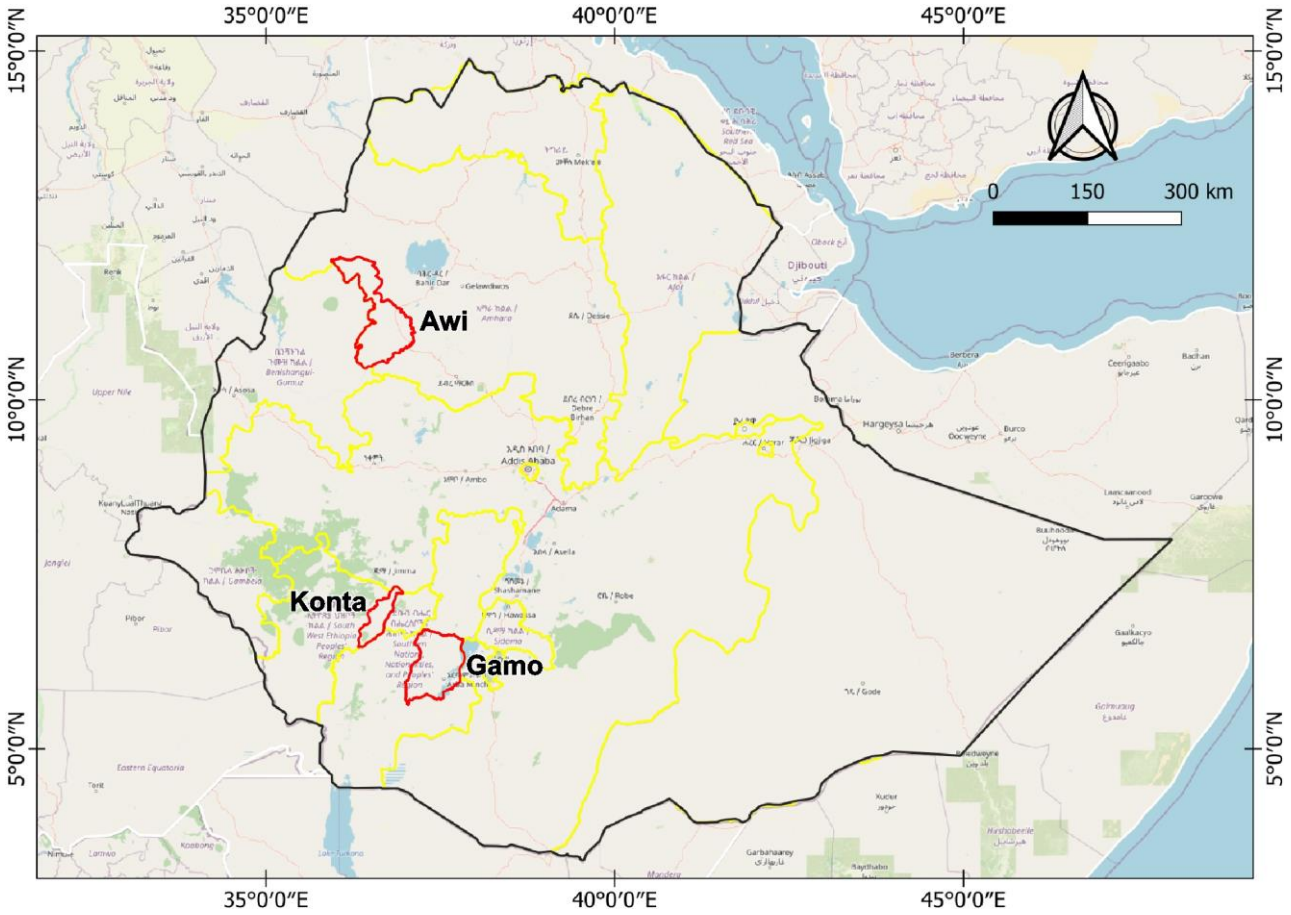


Figure 1. Map of the study area showing the sampled zones in Ethiopia

Table 1. The general profile of respondents by region, woreda, gender, and level of education

Variable region	1	1	1	2	2	2	Overall (*n* = 90)
Woreda	Banja	Guangua	Zigem	Bonke	Chencha	Konta	Total
Number of Respondents	15	15	15	15	15	15	90
Male	10	6	10	8	9	11	54
Female	5	9	5	7	6	4	36
Mean household age	38.3	44.3	41.6	34.8	39.4	42.4	40.1±1.2
Educational status							
No formal education	4	9	6	4	3	9	35
Primary education	3	1	5	3	6	4	22
Secondary education	1	3	2	5	2	1	14
College and above	7	2	2	3	4	1	19

Region 1= Amhara; Region 2= SNNP

RESULTS AND DISCUSSION

Zootherapeutic animals and animal products used by people in the sampled areas

In this study, 20 vertebrate species belonging to 11 orders, in 15 families, and 19 genera were recorded to cure nearly 23 human aliments by Awi, Gamo, and Konta communities. The species and their uses, mode of remedy preparation, common English, local and scientific names, and their conservation status can be seen in Table 2. Ethnozoological studies in different parts of the world revealed the use of animal species and their products as a cure for human and livestock diseases in diverse cultural and tribal settings (Alves and Rosa 2005; Alves 2012; Altaf et al. 2018). Considering a few recently published findings, Budjaj et al. (2021) reported the use of 31 species in Northwestern Africa. Twenty-three (23) medicinal animal species was reported in the Tehuacan-Cuicatlan Valley, Mexico (Zarazua-Carbajal et al. 2020). Our study revealed the use of 20 vertebrate animal species to treat nearly 23 different human diseases, which is closer to the findings reported in different regions of Ethiopia (Tsegazeabe 2012; Dereje and Chane 2014; Mulugeta et al. 2021). However, variations in the number of medicinal animals were common in different corners of the country. For instance, 51 species were reported by Kendie et al. (2018) in Metema Woreda, while Mekides and Mosissa (2020) reported 17 species around Leka Dullecha District, Western Ethiopia. The relatively lower number of medicinal animals in our study might be related to the lack of traditional healers as key informants in the study.

Mammals (n= 14) were among the most commonly used zootherapeutic species, followed by birds (n= 4) (Figure 2 and Table 2). Among them, hyena, bushbuck, and francolin were the commonly used medicinal animals in the Amhara region, while porcupine, warthog, and hyena were commonly reported in SNNPR (Figure 3). However, hyena, porcupine, and bushbuck remained important medicinal animals in the study areas, with the overall use value of 0.33, 0.31, and 0.26, respectively (Table 2). The dominant use of mammals and their parts for zootherapeutic purposes across the study localities in our study is comparable with the results reported in Northwestern Africa (Budjaj et al. 2021), Southern Regions of Pakistan (Mussarat et al. 2021), Brazil (Alves et al. 2011), India (Borah and Prasad 2017), Mexico (del Valle et al. 2015; Zarazua-Carbajal et al. 2020), Pakistan (Altaf et al. 2018) and Nepal (Adhikari et al. 2020). Similarly, a higher frequency of mammalian use in the TM among diverse communities was also reported in different parts of Ethiopia (Tsegazeabe 2012; Dereje and Chane 2014; Kendie et al. 2018; Manaye et al. 2021; Mulugeta et al. 2021). As reported by multiple authors (e.g., Altaf et al. 2018; Budjaj et al. 2021; Adhikari et al. 2020), avian species have more traditional medicinal importance next to mammals, which is in line with our findings. The higher medicinal use value of mammals and birds might be attributed to the higher degree of interaction with humans in the cultural and traditional ceremonies (Vijayakumar et al. 2015; Zarazua-Carbajal et al. 2020). Although reptiles are broadly used animal resources in the TM (Alves et al. 2007; Nijman and Bergin 2017; D'Cruze et al. 2020; Boakye et al. 2021), we found only one species (python) to treat rabies and general body swellings. This might be attributed to the lack of involvement of traditional healers in our study.

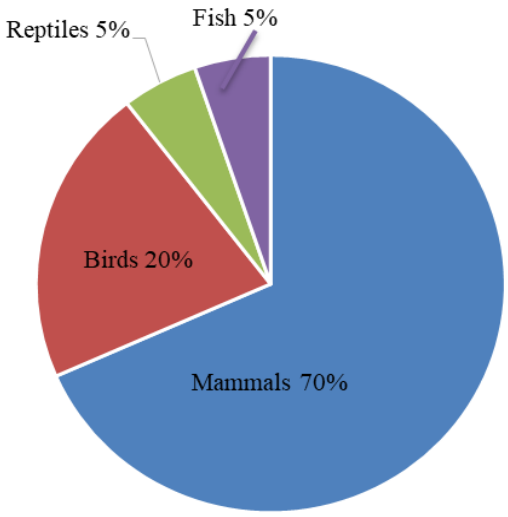


Figure 2. The proportion of commonly used zootherapeutic vertebrate classes for traditional medicine

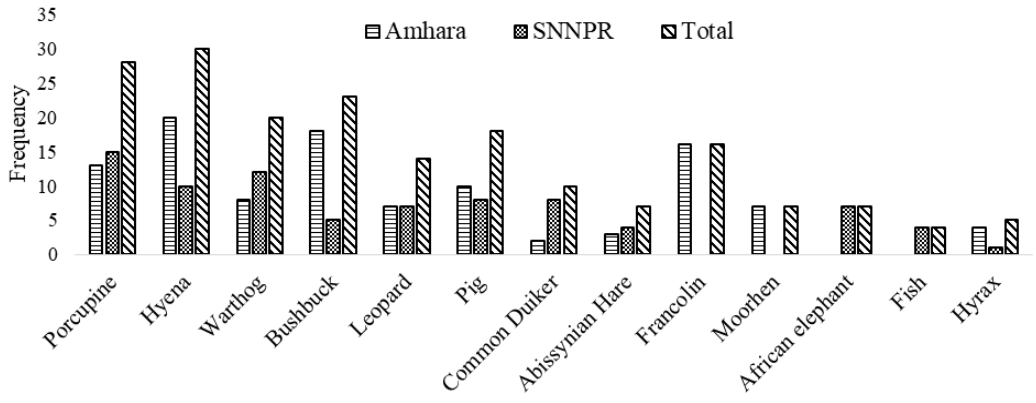


Figure 3. Frequency of commonly used zootherapeutic animals for traditional medicine across sampled regions

Table 2. Ethnomedicinal knowledge of animal resources among communities in the study areas

Scientific name	Common name (E)	Local name (A/Am/G/K)	Class	Parts used	Uses in Amhara	Uses in SNNPR	Mode of preparation	Use value (UV)	IUCN* Conservation status
Hystrix cristata (Linnaeus, 1758)	Crested porcupine	Giretsa (A); Quttarssa (G, K)	Mammals	Meat	Asthma, coughing horse	Asthma, pneumonia	Soup/ meat dried, crushed and given to infected horses	0.31	LC
Crocuta crocuta (Erxleben, 1777)	Spotted hyena	Ehuy (A); Godare (G)	Mammals	Eyelash,skin, bile	Protection from evil eye & bad sprit	Protection from evil eye	Skin dried and placed in the house/tying on the body, bile given for the patient	0.33	LC
Phacochoerus aethiopicus (Pallas, 1766)	Desert warthog	Tsigini (A); Gashoo (K)	Mammals	Meat	Broken bone	Breast infection, broken bone, bone ache	Soup	0.22	LC
Tragelaphus scriptus (Pallas, 1766)	Bushbuck	Dekuli (A)	Mammals	Meat	Broken bone	Source of bush meat	Roasted meat, soup,	0.26	LC
Panthera pardus (Linnaeus, 1758)	Leopard	Tsaneh (A)	Mammals	Meat	Rabies	---	Fatty part of fresh meat is roasted and given to the infected person	0.16	VU
Potamochoerus larvatus (F.Cuvier, 1822)	Bushpig	Geremi (A); Gudunttaa (K)	Mammals	Meat	Broken bone, leg swelling due to kidney infection	Body swellings due to infections, TB	Soup	0.2	LC
Sylvicapra grimmia (Linnaeus, 1758)	Common Duiker	Kupetsa (A); Gense (G)	Mammals	Soup	Asthma	Bone ache	Soup	0.11	LC
Lepus habessinicus Hemprich & Ehrenberg, 1832	Abyssinian Hare	Shenetili (A); Azzo (G)	Mammals	Meat/fur	Skin burn, cattle fattening	Kidney infection, heart failure	Fur is placed in a burnt skin, soup for emaciated cattle	0.08	LC
Pternistis erckelii (Ruppell, 1835)	Erckel's Francolin	Gogocha (A)	Birds	Meat	Asthma, cough	---	Soup	0.18	LC
Paragallinula angulata (Sundevall, 1851)	Moorhen	Ahudera (A)	Birds	Fresh blood	Bleeding skin infections	---	Fresh blood poured over the infected skin surface	0.08	LC
Lates niloticus (Linnaeus, 1758)	Nile perch	Nech Assa (Am)	Fish	Meat	---	Common cold, flu	Roasted meat, soup	0.04	LC
Procavia capensis (Pallas, 1766)	Rock hyrax	Kokach (A)	Mammals	Soup	Asthma, pneumonia	General body illness	Soup, roasted meat	0.06	LC
Numida meleagris (Linnaeus, 1758)	Guinea fowl	Jigra (Am)	Birds	Meat, egg	---	Ritual purpose,	Meat, egg	0.04	LC
Tragelaphus strepsiceros (Pallas, 1766)	Grater Kudu	BerahiwAgazen (A)	Mammals	Meat	Broken bone	Broken bone	Meat, soup	0.04	LC
Syncerus caffer (Sparrman, 1779)	Buffalo	Gosh (Am); Mentta (K)	Mammals	Meat	---	Source of bush meat	Meat, soup is consumed	0.02	NT
Leptailurus serval (Schreber, 1776)	Serval cat	Mahe (G)	Mammals	Meat	---	High fever	---	0.03	LC
Civettictis civetta (Schreber, 1776)	African Civet	Tirigne (Am)	Mammals	Meat/ musk	---	Headache	Smelling fresh musk	0.01	LC
Milvus migrans (Boddaert, 1783)	Black kite	Tsila (A)	Birds	Feather	Ear infection	---	Cleaning the infected ear using soft feather	0.01	LC
Python sebae (Gmelin, 1789)	Python	Dawe (G)	Reptiles	Meat, bone	---	Rabies, body swellings	Soup, heated bone will placed on the swellings	0.01	CE
Loxodonta africana (Blumenbach, 1797)	African elephant	Dangarssa (G, K)	Mammals	Dropping	---	Asthma	Inhaling the smoke of dry faces	0.07	VU

Note: A= Awinin language, Am= Amharic language; G= Gamo language, K= Konta language, CR= Critically endangered, EN= Endangered; LC= Least concern, NT= Near threatened, and VU= Vulnerable

Asthma, protection for evil eye, and broken bone were the most commonly reported diseases in the sampled areas. Where asthma and broken bone were treated by animal products derived from multiple species (Table 2). Although Abyssinian hare was reported to have one of the lowest UV (0.01), the species was used to treat ailments like skin burn, kidney infection, and heart failure. Moreover, the meat of porcupine and hare were involved in treating cough in horses and a source of body weight gain ingredient in emaciated cattle, respectively. However, the meat of buffalo and bushbuck was exclusively reported as a source of bush meat in the study communities.

Among the 20 medicinal animals involved in the TM, four species were listed on the IUCN Red List of threatened species (version 2021-3). The leopard (*Panthera pardus* Linnaeus, 1758) is vulnerable, the African buffalo (*Syncerus caffer* Sparrman, 1779) is near threatened, the African elephant (*Loxodonta africana* Blumenbach, 1797) is vulnerable, and the python (*Python sebae* Gmelin, 1789) is critically endangered (Table 2). The population of such species is declining due to poaching by the local communities for their body parts. For instance, the tusks of elephants and the skin of leopards are international resources traded in the illegal wildlife market (’t Sas-Rolfes et al. 2019; Gubbi et al. 2020), while buffalo and python are poached for bush meat and other cultural values within the community. The declining trend in such globally vulnerable and threatened wildlife populations demand urgent conservation interventions in terms of biodiversity conservation and ethnozoological point of view.

Meat, skin, and blood were the most frequently listed remedial animal products used by the local communities, with the pooled RFC of 0.48, 0.28, and 0.13, respectively (Table 3). The dominant use of meat, either roasted or prepared as soup, in our study, is in agreement with previous studies in Northern Ethiopia (Tsegazeabe 2012; Kendie et al. 2018; Mussarat et al. 2021). The use of soup prepared from the meat of warthog, bushbuck, and bush pig as a remedy for a broken bone in our study might be related to the higher protein and fat content of the meat, which promotes building up processes around damaged tissues. The remedy preparation and administration method vary based on the type of infection and complications developed. As reported by different authors (Souto et al. 2011; Tsegazeabe 2012; Dereje and Chane 2014; del Valle et al. 2015; Altaf et al. 2018; Manaye et al. 2021) the medicinal materials were used either raw or in cooked form, administered orally, smelled or topical as reported by the sampled respondents. Accordingly, the meat of different animals was used orally for various ailments, the elephant dung was dried, crushed, placed on a fire, and smelled for asthmatic conditions, while the fur of Abyssinian hare was placed topically on the surface of a burnt body part.

The general binary logistic regression model revealed that all four variables (i.e., age, education, gender, and region) were important to predicting respondents’ knowledge ($\chi 2$=32.95; *df*=8; P=0.0001). However, of the four variables used in the general model, only age ($\chi 2$=10.53; *df*=3; P=0.01) and region ($\chi 2$=5.11; *df*=1; P=0.02) have significantly influenced ethnozoological knowledge of respondents in the sampled areas (Table 4). For example, respondents’ knowledge in the Amhara region (RE 1) of TM is 1.4 times higher than that of respondents in SNNPR. Similarly, respondents’ knowledge of TM in those age groups less than 30 years (AGC 1) is 2.6 times lower than in old age classes.

The current finding showed that younger respondents have lesser knowledge regarding the use of wild animals towards TM compared with older age groups (Borah and Prasad 2017; Adhikari et al. 2020; Mussarat et al. 2021). Such knowledge variation related to age increment might be linked with accumulated life experiences and skills (Mussarat et al. 2021). Moreover, respondents from the Amhara region have better knowledge about the importance of wild animals in TM than respondents in the Southern region. Therefore, such knowledge variations could be related to the older age of respondents sampled in Amhara than Southern region and might also relate to the cultural affinity of the Amhara community towards wildlife.

Regarding the FGDs, all focus group discussants in each region confirmed wild animals were an important input for TM in their respective localities. For instance, discussants in the Awi zone Amhara region underlined the loss of “stingless bee” (*Trigona* spp.) resulted in the loss of a special kind of honey, locally termed as *“Tazima mar,”* that was harvested from the species. This honey was reported to have an essential medicinal value in the community. Therefore, residents suffered a lot due to the local extinction of the species and its product. They have also stressed the role of birds as important biological pest control agents. The discussants remembered the locust outbreak that occurred during the crop harvesting seasons of 2020 and indicated that birds were the only source to combat the outbreak. The group discussants elaborated that the unidentified bird species arrived simultaneously with the arrival of the swarm of locusts and preyed on them so that the crop damage and loss by the locust had significantly decreased. A senior discussant described the situation as follows “we have nothing to harvest in that season unless the birds preyed up on the locusts, and we believe the arrival of the birds was a miracle from God to safeguard our crops and our lives.” Moreover, discussants in SNNPR confirmed that buffalo and grater kudu remained an important source of bush meat besides the role in the TM. Remarkably, all group discussants agreed on relatively higher incidences of human-wildlife conflict in their respective localities. Hence, almost all the discussants concluded that the important wildlife species are threatened mainly due to poaching, deforestation, habitat destruction, and loss.

Table 3. Relative Frequency of Citation (RFC) of animal body parts used for traditional medication in the studied areas

Animal part or product used	No. of citation in Amhara Region	No. of citation in SNNPR	RFC in Amhara (%)	RFC in SNNPR (%)	Total RFC (%)
Meat	24	20	0.26	0.22	0.48
Skin	16	10	0.17	0.11	0.28
Blood	12	-	0.13	-	0.13
Bile	7	-	0.08	-	0.08
Feather	-	2	-	0.02	0.02

Table 4. SAS output of the predictor variables used in the binary logistic regression model

Variables used	Variable level	Degree of freedom	Estimate	Chi square value	P-value
AGC, ED, GE, RE	---	8	---	32.95	0.0001**
ED	1	1	0.4237	0.2147	0.6431
ED	2	1	0.1370	0.0278	0.8675
ED	3	1	1.0761	1.4342	0.2311
GE	0	1	0.2251	0.1381	0.7102
AGC	1	1	-2.6375	6.9839	0.0082**
AGC	2	1	-1.4674	2.3743	0.1233
AGC	3	1	0.4981	0.1455	0.7029
RE	1	1	1.4065	5.1124	0.0238**

Note: AGC=age category; ED=education; GE=gender; RE=region of respondent. ED 1= respondent with no formal education, ED 2= primary education, ED 3= secondary education, GE 0= female respondents, AGC 1= age group $\leq$ 30, AGC 2= age group $\leq$ 40, AGC 3= age group $\leq$ 50, RE 1= Amhara region. Values with double stars** refer to variables having statistical significance

In conclusion, this study confirmed local communities' unique knowledge and experience regarding animal-based TM. In all the sampled areas, zootherapeutic practices remained a vital component of communal health care systems. In comparison, a relatively higher number of zootherapeutic animals were reported in Amhara compared with the Southern region. Among the reported species, hyena, porcupine, and bushbuck were the important medicinal animals in the study areas with higher use values. The wild animals, besides their role in the TM, are important sources of bush meat and have cultural and spiritual values. Although the wildlife population is an important asset to the community in terms of TM and socio-economic values, the population is decreasing over time. All these call for community conservation education campaigns to achieve sustainable wildlife utilization practices in the study areas. Since the study revealed the unexplored communal knowledge regarding animal-based TM, an intensive study involving knowledgeable traditional healers as key informants is recommended. Moreover, to maintain the intact indigenous community knowledge, emphasis should be given to older age groups in designing similar studies in the future.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the financial and logistic support from the Ethiopian Biodiversity Institute, Animal Biodiversity Directorate. Our gratitude and appreciation go to natural resource experts in Awi and Gamo Zones and Konta Special Woreda. We are also thankful to all respondents in the study area for sharing their ethnozoological knowledge. Our special thanks also go to our drivers, Mr. Abebe Minwuye and Mr. Samson Kebede, for their unreserved support during the fieldwork. We also appreciate Mr. Tadesse Hunduma's assistance in developing the study area map. Finally, we want to acknowledge the two anonymous reviewers for the time and effort devoted to improving the quality of the paper.

REFERENCES

't Sas-Rolfes M, Challender DWS, Hinsley A, Veríssimo D, Milner-Gulland EJ. 2019. Illegal wildlife trade: Scale, processes, and governance. Ann Rev Environ Resour 44: 201-228. DOI: 10.1146/annurev-environ-101718-033253.

Adhikari JN, Bhattarai BP, Rokaya MB, Thapa TB. 2020. Ethno-medicinal uses of vertebrates in the Chitwan-Annapurna Landscape, central Nepal. PLoS One 15 (10): e0240555. DOI: 10.1371/journal.pone.0240555.

Albuquerque UP, Silva JS, Campos JLA, Sousa RS, Silva TC, Alves RRN. 2013. The current status of ethnobiological research in Latin America: Gaps and perspectives. J Ethnobiol Ethnomed 9: 72. DOI: 10.1186/1746-4269-9-72.

Altaf M, Umair M, Abbasi AR, Muhammad N, Abbasi AM. 2018. Ethnomedicinal applications of animal species by the local communities of Punjab, Pakistan. J Ethnobiol Ethnomed 14: 55. DOI: 10.1186/s13002-018-0253-4.

Alves R, Rosa IL. 2005. Why study the use of animal products in traditional medicines? J Ethnobiol Ethnomed 1: 5. DOI: 10.1186/1746-4269-1-5.

Alves RRN, Alves HN. 2011. The faunal drugstore: Animal-based remedies used in traditional medicines in Latin America. J Ethnobiol Ethnomed 7: 9. DOI: 10.1186/1746-4269-7-9.

Alves RRN, Barbosa JA, Santos SL, Souto W, Barboza RR. 2011. Animal-based remedies as complementary medicines in the semi-arid region of northeastern Brazil. Evid Based Complement Alternat Med DOI: 10.1093/ecam/nep134.

Alves RRN, Filho GAP, Delima YCC. 2007. Snakes used in ethnomedicine in Northeastern Brazil. Environ Dev Sustain 9: 455-464. DOI: 10.1007/s10668-006-9031-x.

Alves RRN. 2012. Relationships between fauna and people and the role of ethnozoology in animal conservation. Ethnobio Conserv 1: 1-69. DOI: 10.15451/ec2012-8-1.2-1-69.

Bekalo TH, Woodmatas SD, Woldemariam ZA. 2009. An ethnobotanical study of medicinal plants used by local people in the lowlands of Konta Special Woreda, southern nations, nationalities and peoples regional state, Ethiopia. J Ethnobiol Ethnomed 5: 26. DOI: 10.1186/1746-4269-5-26.

Boakye MK, Wiafe ED, Ziekah MY. 2021. Ethnomedicinal use of pythons by traditional medicine practitioners in Ghana. Afr J Herpetol 70: 2. DOI: 10.1080/21564574.2021.1976288.

Borah MP, Prasad SB. 2017. Ethnozoological study of animals basedmedicine used by traditional healers and indigenous inhabitants in the Adjoining Areas of Gibbon Wildlife Sanctuary, Assam, India. J Ethnobiol.Ethnomed 13: 39-13. DOI: 10.1186/s13002-017-0167-6.

Budjaj A, Benitez G, Pleguezuelos JM. 2021. Ethnozoology among the Berbers: Pre-Islamic practices survive in the Rif (Northwestern Africa). J Ethnobiol Ethnomed 17: 43. DOI: 10.1186/s13002-021-00466-9.

Caudell MA, Quinlan MB, Quinlan RJ, Call DR. 2017. Medical pluralism and livestock health: Ethnomedical and biomedical veterinary knowledge among East African agro-pastoralists. J Ethnobiol Ethnomed 13 (7): 6. DOI: 10.1186/s13002-017-0135-1.

d'Avigdor E, Hans W, Zemede A, Tesfaye A. 2014. The current status of knowledge of herbal medicine and medicinal plants in Fiche, Ethiopia. J Ethnobiol Ethnomed 10: 38. DOI: 10.1186/1746-4269-10-38.

D'Cruze N, Assou D, Coulthard E, Norrey J, Megson D, Macdonald DW, Harrington LA, Ronfot D, Segniagbeto GH. Auliya M. 2020. Snake oil and pangolin scales: Insights into wild animal use at "Marché des Fétiches" traditional medicine market, Togo. Nat Conserv 39: 45-71. DOI: 10.3897/natureconservation.39.47879.

del Valle YG, Naranjo EJ, Caballero J, Martorell C, Ruan-Soto F, Enríquez PL. 2015. Cultural significance of wild mammals in Mayan and Mestizo communities of the Lacandon Rainforest, Chiapas, Mexico. J Ethnobiol Ethnomed 11: 1. DOI: 10.1186/s13002-015-0021-7.

Dereje WY, Chane M. 2014. Ethnozoological study of traditional medicinal animals used by the Kore people in Amaro Woreda, Southern Ethiopia. Intl J Mol Evol Biodivers 4 (2): 1-9.

Elias AS, Tesfaye G, Bizatu M. 2013. Aspects of common traditional medical practices applied for under-five children in Ethiopia, Oromia Region, Eastern Harargie District, Dadar Woreda, 2011 G.C. J Community Med Health Educ 3 (6): 237. DOI: 10.4172/2161-0711.1000237.

Getachew A, Dawit A, Timotewos G, Kelbessa U. 2002. Perceptions and practices of modern and traditional health practitioners about traditional medicine in Shirka District, Arsi Zone, Ethiopia. Ethiop J Health Dev 16 (1): 19-29. DOI: 10.4314/ejhd.v16i1.9823.

Getaneh G, Teshome S, Tesfaye B, Demel T. 2019. Carbon stocks and factors affecting their storage in dry Afromontane forests of Awi Zone, northwestern Ethiopia. J Ecol Environ 43: 7. DOI: 10.1186/s41610-019-0105-8.

Gochera A, Shibru S, Kechero Y. 2020. Woody fodder species in three agro-ecological Parklands of Arba Minch Zuria Woreda, Gamo Gofa Zone, Southern Ethiopia. Intl J Biodivers Conserv 12 (1): 38-47. DOI: 10.5897/IJBC2019.1305.

Gubbi S, Kolekar A, Kumara V. 2020. Policy to on-ground action: Evaluating a conflict policy guideline for leopards in India. J Intl Wildl Law Policy 23 (2): 127-140. DOI: 10.1080/13880292.2020.1818428.

Hernandez J, Campos CM, Borghi C. 2015. Medicinal use of wild fauna by mestizo communities living near San Guillermo Biosphere Reserve, (San Juan, Argentina). J Ethnobiol Ethnomed 11: 15. DOI: 10.1186/1746-4269-11-15.

Kefalew A, Asfaw Z, Kelbessa E. 2015. Ethnobotany of medicinal plants in Ada'a District, East Shewa Zone of Oromia regional state, Ethiopia. J Ethnobiol Ethnomed 11: 25. DOI: 10.1186/s13002-015-0014-6.

Kendie FA, Mekuriaw SA, Dagnew MA. 2018. Ethnozoological study of traditional medicinal appreciation of animals and their products among the indigenous people of Metema Woreda, North-Western Ethiopia. J Ethnobiol Ethnomed 14: 37. DOI: 10.1186/s13002-018-0234-7.

Manaye M, Nigusie S, Abiyesilassie M. 2021. Documentation of traditional knowledge associated with medicinal animals in West Gojjam Zone of Amhara Region, Ethiopia. Am J Life Sci 9 (3): 45-54. DOI: 10.11648/j.ajls.20210903.12.

Mardiastuti A, Masy'ud B, Ginoga LN, Sastranegara H, Sutopo. 2021. Short Communication: Wildlife species used as traditional medicine by local peoplein Indonesia. Biodiversitas 22: 329-337. DOI: 10.13057/biodiv/d220140.

Mekides T, Mosissa GE. 2020. Indigenous ethnozoological and ethnoveterinary medicinal practices in Leka Dullecha District, Western Ethiopia. Glob Vet 22 (5): 286-297.

Mishra N, Rout SD, Panda T. 2011. Ethnozoological studies and medicinal values of Similipal Biosphere Reserve, Orissa, India. Afr J Pharm Pharmacol 5 (1): 6-11.

Mootsamy A, Mahomoodly M.F. 2014. A quantitative ethnozoological assessment of traditionally used animal based therapies in the tropical island of Mauritius. J Ethnopharmacol 154 (3): 847-857. DOI: 10.1016/j.jep.2014.05.001.

Mulugeta K, Erchafo M, Meyer-Rochow VB. 2021. Knowledge and use of traditional medicinal animals in the Arba Minch Zuriya District, Gamo Zone, Southern Ethiopia. Eur J Ther 72 (2): 158-167. DOI: 10.5152/eurjther.2021.20064.

Mussarat S, Ali R, Ali S, Mothana RA, Ullah R, Adnan M. 2021. Medicinal animals and plants as alternative and complementary medicine in Southern Regions of Khyber Pakhtunkhwa, Pakistan. Front Pharmacol 12: 649046. DOI: 10.3389/fphar.2021.649046.

Nijman V, Bergin D. 2017. Reptiles traded in markets for medicinal purposes in contemporary Morocco. Contrib Zool 86 (1): 39-50. DOI: 10.1163/18759866-08601003.

Phillips O, Gentry AH. 1993. The useful plants of Tambopata, Peru: I. Statistical hypotheses tests with a new quantitative technique. Econ Bot 47: 15-32. DOI: 10.1007/BF02862203.

Souto W, Mourao JS, Barboza RRD, Alves RRN. 2011. Parallels between zootherapeutic practices in Ethnoveterinary and Human Complementary Medicine in NE Brazil. J Ethnopharmacol 134 (3): 753-767. DOI: 10.1016/j.jep.2011.01.041.

Tsegazeabe H. 2012. Traditional zootherapeutic studies in Degu'a Tembien, Northern Ethiopia. Curr Res J Biol Sci 4 (5): 563-569.

Vijayakumar S, Morvin Yabesh JE, Prabhu S, Ayyanar M. 2015. Ethnozoological study of animals used by traditional healers in Silent Valley of Kerala, India. J Ethnopharmacol 162: 296-305. DOI: 10.1016/j.jep.2014.12.055.

Zarazua-Carbajal M, Chavez-Guterrez M, Romero-Bautista Y, Rangel-Landa S, Moreno-Calles AI, Ramos LFA, Smith SE, Blancas J, del Val E, Arizmendi M, Casas A. 2020. Use and management of wild fauna by people of the Tehuacan-Cuicatlan Valley and surrounding areas, Mexico. J Ethnobiol Ethnomed 16: 4. DOI: 10.1186/s13002-020-0354-8.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 5, Number 2, November 2022 E-ISSN: 2580-4510
Pages: 92-101 DOI: 10.13057/asianjethnobiol/y050203

Documentation of the plants used in different Hindu rituals in Uttarakhand, India

SATISH CHANDRA♥
Department of Botany, Government Degree College Tyuni. Dehradun, Uttarakhand 248199, India.
Tel.: +91-1360-285180, ♥email: satishchandrasemwal07@gmail.com

Manuscript received: 1 March 2022. Revision accepted: 21 July 2022.

Abstract. *Chandra S. 2022. Documentation of the plants used in different Hindu rituals in Uttarakhand, India. Asian J Ethnobiol 5: 92-101.* Hinduism is one of the largest practicing religions. The Indian subcontinent is the cradle of this religion, and it is followed by a majority of the people of the subcontinent. Rituals are the main component of the Hindu tradition. Any ritual is a way to connect with God and offer salutation. From birth to the death of a person, one has to perform various rituals on enormous occasions. Methodology and material used in a ritual vary as per the presiding deity. In the sacrifice (Yajyan) and other worship procedures stage (Mandapa), different utensils and materials required to complete the rituals originated from plant products. These products represent the environmental and geographical structure of the area. Documentation of the plant species used in different Hindu rituals is done in the present article. A total of 104 plant species are enumerated. The use of plant species individually or in combination with others is also elaborated. Some terms used in the rituals, such as Panch Pallav, Panch Mewa, Saptanaja, Tambula, Panchamrita, Ashtha Bali, etc., which have botanical significance, are also discussed.

Keywords: Havishya, Hindu tradition, Navgraha, Samvidha, Yajyan

INTRODUCTION

Religions and faiths have generated enormous mechanisms to offer their salutations to the creator, which is called God. From the Vedic time (c. 1500-c. 500 BCE), the people of the Indian subcontinent have devised various procedures to offer homage to different components of nature. Various constituents of nature are worshiped as deities viz. earth (Goddess Prithvi), daytime (God Mitra), sky (God Dhyawa), wind (God Marut), sun (God Surya), fire (God Agni), dawn (Goddess Usha), darkness (Goddess Ratri), water (God Varuna), moon (God Chandrama), plants (God Vanaspati) and forest (Goddess Aranyani), etc. (Acharya and Sharma 2018a,b,c,d). Along with the evolution of understanding about the importance of different components of nature, people started to develop different procedures to mark respect towards them and seek blessing from them. As time passed, these procedures turned into rituals.

Rituals are the main component of the Hindu tradition. From birth to the death of a person, one has to perform various rituals on enormous occasions (Drabu 1990). Some rituals are performed by an individual, and some by a group of people. In the rituals, various animal products and plant parts are used. Vedic people used those plants and animal products in the rituals available in their vicinity, and modern Hindu societies still follow that practice. The cow was the main source of livelihood for Vedic people, and various products of a cow, such as milk, curd, clarified butter, urine, and fresh cow dung, were used in the rituals (Acharya and Sharma 2018a). Similarly, plants of Indian origin, such as mango, banana, coconut, banyan, holy basil, peepal, rice, black gram, etc., are primarily used in the rituals. Based on their usage in the rituals, most of these plants and animals are considered more sacred than the others. Some of the plants and animal products are considered very important when performing the rituals, meaning that in the absence of these products, rituals cannot be completed.

Rituals are dynamic in nature people do not strictly follow the scriptures to perform rituals, rather, over generations, they have developed various alternatives based on the availability of the resources in the area. Therefore, the plant products used in rituals represent the environmental and geographical structure of the area (Acharya 2014). For instance, the coconut fruit is considered sacred and used in many rituals, but in the hilly areas of northern India, in some rituals, it is replaced by the lime fruit. This was due to the unavailability of coconut fruit in hilly northern India, so people started using other fruits.

As the social structure and lifestyle of the people are changing, the core structure of rituals is also changing. The priests (Pandits) and old aged people are the main stakeholders of this knowledge, along with the shopkeepers (Pansari) who sold these items. Due to the changed lifestyle and influence of the western culture younger generation considers the traditional rituals less practical. Simultaneously, the limited availability of plant-based products further graves the condition. Transfer and accumulation of such knowledge are not happening to the young generation, who knows very less about plants used in rituals and their importance. The use of plastic is also a threat to this knowledge. Traditionally bowls, plates, and other utensils used in different rituals were prepared from plant-based

products. Yet, these items are being replaced with plastic-based products. As a consequence, traditional knowledge related to many such products is vanishing day by day.

There have been various articles on the documentation of the plants mentioned in the Vedas, Mahabharata, Ramayana, and other sacred Hindu texts (Agrawala 1952; Deb 1955; Dhiman 2003; Arya 2007; Amirthalingam 2013; Varma 2015; Balkrishna et al. 2019; Tripathi 2019) but no article represents the plants used in the different rituals. In the present work, author aimed to document different plants used in the different rituals. This knowledge can be useful for protecting certain locally grown species and awareness of their importance.

MATERIALS AND METHODS

Study area

The study was conducted in Uttarakhand, a hilly state in India. Uttarakhand comprises wide geographical variation from plain areas and various mountain ranges to mighty snow-covered Himalayan peaks. Conventionally, the state is known as Dev Bhumi (Abode of Gods) due to the presence of a large number of Hindu sacred sites (Tirtha) and mentioning of the areas in the various scriptures as Mahabharata and Puranas.

Procedures

From various sacred scriptures (Vedas, Puranas, and Samhitas), procedures of performing different rituals were compiled into a single book in the Hindu tradition. Such books are considered a protocol for the rituals and are known by numerous names as Pooja Bhaskar, Nitya Karmakand Pooja, Karmakand Bhaskar, etc. Such books by Sharma (1985; 1990; 1991; 1995), Khemka (1993), Shastri (1999; 2016), Acharya (2014), Chaturvedi (2015), Gaur (2015), and Avasthi (2020) were referred for the present study. Apart from these, some other books by Mishra (2001), Girdharwal (2006), Sharma (2008), Verma et al. (2009), Pandey et al. (2011), Narayan (2012), Srimali (2015), Shastri (2016), Gaur et al. (2018), and Dixit (2019) deals with the methods of worship and sacrifice (Yajyan) of various deities were also consulted. Data for the present work was also gathered through interviewing 160 people, including the priests (Pandits), old people, shopkeepers (Pansari), and young people in the study area.

RESULTS AND DISCUSSION

Hindu rituals broadly come under two categories Vedic and Tantric rituals. Vedic rituals strictly follow the Vedas. In contrast, Tantric rituals are rooted in the Vedas but have variations in the methodology. Vedic and Tantric rituals follow the Nigama and Agama literature, respectively (Drabu 1990). Rituals can be a ceremony (Samskara) or worship procedure (Pooja) of a deity. The deities are further classified into various categories. These can be any God as Rama, Shiva, Vishnu, Brahma, etc. or Goddess as Durga, Laxmi, Saraswati, etc., or component of nature as water (Varuna), earth (Prithvi), wind (Vayu), fire (Agani), river (Nadi), etc. or the nine planets (Navgraha) as the sun (Surya), Jupiter (Brhaspati), mercury (Budha), venus (Shukra), etc. or the ancestors (Pitra deva) (Acharya and Sharma 2018a).

The core philosophy of Hinduism believes in one supreme God called (Brahma or Brahman), and all the Gods (Deva), living beings (Jeeva), and matters (Padartha) are considered a manifestation of him (Radhakrishnan 2018). Therefore, any ritual is a way to connect with him and offer salutation. Methodology and material used in a ritual have variations as per the presiding deity of the ritual. Therefore, rituals of different deities have different steps (Drabu 1990). Some steps include the formation of a stage (Mandapa) for deities, offering of fragrance (Dhoop), lighting of lamp (Deep), worship of five prominent Gods (Ganesh, Vishnu, Shiva, Surya, and Goddess Durga), worship of small water containing utensil (Kalasha), offering of water (Jalam), five elixirs (Panchamirta), offering of cloths (Vastra), Yajyonpavita (Janeu), offering of sandal paste (Chandan), flowers (Pushpam), fruit (Phalam), food (Naivedhya), etc. are usually common in every ritual (Acharya 2014).

Different plant parts or plant-based products are used to form the things above. A list of plants used in the different Hindu rituals is provided in Table 1. A total of 104 plant species are enumerated. All categories of plant species as herbs, shrubs, trees, climbers, and runners are presented in the table. Different plant parts such as root, stem, leaves, flower, fruit, seed, or whole plant of the different species are utilized in various rituals. Common flowers (rose, carnation, dahlia, marigold, etc.) and fruits (guava, citrus, mango, apple, etc.) which are usually offered to deities depending on their season, are not mentioned in the list. These flowers and fruits are termed Hritu Pushpam and Hritu Phalam, respectively (Sharma 1991). These are neither offered to any specific deity nor on a specific occasion but to various deities on every occasion.

Sacrifice is common in every ritual. Sacrifice involves an offering of different materials to the deity. In the sacrifice (Yajyan) over a specific stage (Mandapa), woods are ignited, and oblation is offered to the fire. Meanwhile, Vedic hymns are chanted by the priests (Hritvik). The woods used to ignite the fire are called Samvidha (Acharya and Sharma 2018a). Wood from specific plants mentioned in Table 2 is used for this purpose. In the absence of these plants, wood of plants that do not possess spine or prickles is used. The oblation is known as Havishya or Churu, a mixture of plant products mentioned in Table 3 mixed with clarified butter (Ghee) (Sharma 1990). For the fragrance, mixtures of plant products mentioned in Table 4 are used. In the ancient times, toward the end of sacrifice animal slaying (Pashu Bali) was done in ancient times. But the tradition evolved with time; presently, animal slaying is prohibited and replaced by offering plant products. Usually, the fruit coconut (Nariyal) is used for this purpose (Acharya and Sharma 2018a). In some Tantric rituals, other plant products are also used. Based on plant products, these are classified into two categories, i.e., Makh Bali and Ashtha Bali. In Makh Bali, lamp (Deep), black gram

(Urad), curd (Dahi), vermilion (Sindoor), seasonal flowers, and food (Prasada) are offered to the deities. Makh Bali is usually offered in the rituals performed to get rid of bad spirits and omens. Ashtha Bali is an extended version of the Makh Bali, where eight plant parts or plant-based products are offered to the local deities (Kshetra Pala). Plant parts or products used as Makh Bali and Ashtha Bali are mentioned in Table 5.

Plant products or parts and animal products are sometimes used individually or in combination with others in the rituals and described with specific names. A detail of such combination is provided herein:

Panch Pallav (five sacred leaves)

Leaves of the five sacred plants are decorated on the small water-containing utensil (Kalash). A list of the plants is provided in Table 6.

Panch Mewa (five sacred dry fruits)

For the worship of deities, five sacred dry fruits are offered. A list of the plants is provided in Table 7.

Saptanaja (seven grains)

In some Tantric rituals, grains or seeds of seven plants are mixed and offered to the deity. The combination of these seven grains varies according to the geographical condition and environment of the area. A list of plants used for this purpose is provided in Table 8.

Sarvoshadhi

It is a combination of plant parts and is used for the holy bath of deities. Different plant parts are powdered and mixed with water and milk during the bath of the deity. Plants used for this purpose are provided in Table 9.

Panchamrita (five elixirs)

It is combination of animal and plant-based products and offered to the deities. Holy basil leaves are mixed with milk, curd, clarified butter, and honey or sugarcane. The list of component used for this purposes is provided in Table 10.

Panchagavya (five pious from cow)

In this, five products of cow are mixed and used for the bath and purification of the deity. The list is provided in Table 11.

Figure 1. Images of different rituals. A. Wooden plank (Chauki) decorated for the Ganpati Pooja, B. Various items staged to perform a ritual, C. A Yajyan mandapa, D. Traditional mortar (Okhali) decorated for the ceremony, E. A pot decorated before commencing small scale Yajyan, F. A priest preparing for Yajyan, G. Symbol (Brahmathangur) of the deity held by devotees, H. Traditional Haldi ritual of marriage ceremony.

Table 1. List of the plants used in Hindu rituals in Uttarakhand, India

Plant	Common name	Part use	Use
Abrus precatorius L.	Gunja, Ratti	Fruit, roots	Jeweler used to use fruit as a unit of measurement; pendant of roots worn on neck and waist after invocation to get rid of bad spirits.
Aegle marmelos (L.) Corrêa	Bel, Bilva	Leaves, fruit	Leaf with three leaflets and fruits are offered to God Shiva
Amaranthus caudatus L.	Cholai	Fruit	For the preparation of the food of deities (Prasada); used in the sacrifice (Hawan) of the Goddess Durga
Anaphalis contorta (D.Don) Hook.f.; *Anaphalis* sp.	Bugulu	Flower	Used in the reverence of ancestors (Pitra pooja)
Annona muricata L.	Main Phal	Fruit	It is offered to Goddess Durga
Areca catechu L.	Supari	Fruit	Fruit is venerated; an important component of the Tambula
Asparagus racemosus Willd.	Satavar	Root	It is used in Satoshadhi, during bath of deities
Bauhinia vahlii Wight & Arn.	Malu	Leaves	For the preparation of the plate and bowl used in rituals
Bauhinia variegata L.	Kachnar	Whole tree, flowers	It is believed that the tree is liked by God Vishnu; Flowers are offered to the God
Benincasa hispida (Thunb.) Cogn.	Petha, Bhujyalu	Fruit	Used as an alternative to animal sacrifice (Ashtha Bali); for making food of deities (Prasada)
Betula utilis D.Don	Bhoj Patra	Outer covering of stem bark	Outer covering of stem bark is worshiped; in ancient times due to absence of papers the scriptures were written on the rolls of the these covering
Bombax ceiba L.	Semal	Fruit fiber	Fiber from the fruits is used as an alternative of cotton fiber
Brassica napus L.	Sarson (Kali)	Fruit	For the veneration of ancestors; Used in Tantric tradition to get rid of bad spirits; oil is used in the reverence of planet Saturn (Shani)
Brassica rapa subsp. *campestris* (L.) A.R.Clapham	Sarson (Peeli)	Fruit	For the veneration of ancestors; used in Tantric tradition to get rid of bad spirits; oil is used in the reverence of planet Saturn (Shani)
Butea monosperma (Lam.) Kuntze	Palas, Dhak	Leaves	For the preparation of the plate and bowl used in rituals
Calotropis gigantea (L.) W.T.Aiton	Arka, Madar	Whole plant	Used in the veneration of God Shiva and Ganesha; used in the veneration of planet Sun (Surya); people believe that growing the plant near house protects from bad spirits
Cannabis sativa L.	Bhang	Leaves	Liked by God Shiva; on the occasion of the Maha Shivratri exudates of the leaves mixed with milk and dry fruits (Bhang ghota) and offered to God Shiva and consumed by devotees
Capsicum annuum L.	Mirch	Fruit	Used in Tantric tradition to get rid of bad spirits
Cedrus deodara (Roxb. ex D.Don) G.Don	Deodar	Wood	Used in the sacrifice (Yajyan)
Cicer arietinum L.	Chana Dal	Refined seeds	Offered to the God Vishnu as food (Prasada)
Citrus limon (L.) Burm. f.	Chhota nimbu, Kagaji nimbu	Fruit	On Saturday, fruit of lime and green capsicum (Hari Mirch) are tied together and placed at the gate of the house and shop to get rid of bad spirits and bad omens
Citrus pseudolimon Tanaka	Bada Nimbu	Fruit	Used for the reverence of deities; venerated in the marriage ceremony and donated (as Prasada) for the newly married couple; sometimes also used as a substitute of the coconut fruit; fruit used as an alternative to animal sacrifice (Ashtha Bali)
Clitoria ternatea L.	Parajita	Flower, roots	Roots and flowers are used in Tantric tradition to get rid of bad spirits
Cocos nucifera L.	Nariyal	Leaves, fruit	Leaves are used for the preparation of stage of deities (Mandapa), fruit is venerated; fruit is used as an alternative to animal sacrifice (Ashtha Bali); considering the importance of the fruit it is considered as Shriphal, which means fruit of wealth
Coix lacryma-jobi L.	Vaijanti	Seed	Garland of the seed is revered and it is believed that God Vishnu likes it
Colocasia esculenta (L.) Schott	Arabi	Rhizome	Used as an alternative to animal sacrifice (Ashtha Bali); consumed by devotees during fast (Vrata)
Crocus sativus L.	Keshar	Stigma	Dried stigmas mixed with the paste of sandal (Chandan) and applied to the forehead; stigmas are considered a sign of prosperity and placed at lockers, worship places, and inside the books; it is also used for various purposes in the Tantric tradition
Cucurbita pepo L.	Kaddu	Fruit	Used as alternative of animal sacrifice (Ashtha Bali); for making 56 foods of God Krishna (Prasada)
Curcuma longa L.	Haldi	Rhizome	Yellow paste is used for veneration of ancestors (Pitra pooja) as an alternative of sandal (Chandan); the paste is also considered auspicious and applied before holy bath (Mangal Snan) during marriage and first shaving ceremony (Mundan Samskara) and the ritual is termed as Haldi Hath; un-boiled rhizome used in auspicious occasions as marriage, first shaving ceremony (Mundan Samskara) of boy; in the festival of Chhat

Cynodon dactylon (L.) Pers.	Doob, Durva	Leaves	Important for the veneration of God Ganpati; leaves used in veneration of all deities (Dev pooja) and ancestors (Pitra pooja); used in the veneration of planet Rahu; leaves used for the applying turmeric on the body during auspicious rituals
Dactylorhiza hatagirea (D.Don) Soó	Hattha jodi	Roots	Roots are used in the Tantric tradition for prosperity
Datura stramonium L.	Dhatura	Root, stem, leaves, flower, fruit	Root, stem, leaves, flower and fruit (Panchang) are used for the veneration of God Shiva
Dendrocalamus strictus (Roxb.) Nees	Bans	Bole/stalk	For the preparation of articles of deities as baskets etc., in the reverence of ancestors (Pitra pooja); bole established in the stage of Bhagwat katha; bole used for making symbols of deities as flag, palanquin and altars; for making Arthi of the dead bodies; burning the bole is prohibited; bole is not allowed to keep in the house
Desmostachya bipinnata (L.) Stapf	Kusha	Leaves	Used for preparation of mat (Ashana) of the deities; sacred thread of leaves used in the ancestor reverence (Pitra Pooja); it is considered mandatory in all ancestor reverence, used in the veneration of planet Ketu
Dioscorea bulbifera L.	Genthi	Rhizome, fruit	Used in the Ashtha Bali; consumed by devotees during fast.
Dioscorea deltoidea Wall. ex Griseb.	Tedu	Rhizome, fruit	Used in the Ashtha Bali; consumed by devotees during fast.
Echinochloa frumentacea Link	Jhangora	Seed	Component of the seven grains (Saptanaja) used in Tantric tradition and reverence of ancestors
Elaeocarpus angustifolius Blume	Rudraksh	Fruit	Fruit is worshiped; it is believed that God Shiva love it very much; necklace of fruit is worn by devotees
Elettaria cardamomum (L.) Maton	Ilayachi (chhoti)	Fruit	Used in veneration of deities; an important component of the Tambula
Eleusine coracana (L.) Gaertn.	Mandua	Seed	Component of the seven grains (Saptanaja) used in Tantric tradition and reverence of ancestors
Ferula assa-foetida L.	Hing	Root extract	Mixed with juice of garlic to get rid the bad spirits (Bhoot dosha).
Ficus auriculata Lour.	Timalu	Leaves	For the preparation of the plate and bowl used in rituals
Ficus benghalensis L.	Bargad, Vat	Leaves, wood, prop roots	Leaves are dipped in the sacred utensil Kalash; after reverence, leaves are tied at the main gate of the house and stage of deities (Mandapa); wood is used in sacrifice (Yajyan), wood of prop roots is used for the preparation of decoction offered to the pregnant lady during Punsavan Samskar
Ficus racemosa L.	Gular	Leaves, wood	Leaves are dipped in the sacred utensil Kalash; after reverence, leaves are tied at the main gate of the house and stage of deities (Mandapa); wood is used in sacrifice (Yajyan); for the sacrifice of the planet Venus (Shukra)
Ficus religiosa L.	Peepal, Ashwatha	Whole tree, leaves, wood	One of the sacred trees in Hindu tradition; in the sacred scripture Srimad Bhagavad Gita God Krishna told that he is peepal amongst the tree; leaves dipped in the sacred utensil Kalash after reverence leaves are tied at the main gate of the house and stage of deities (Mandapa); wood is used in sacrifice (Yajyan); dried twigs are used in the reverence of planet Jupiter (Brhaspati); whole tree is venerated on the Saturday (Shaniwar) and new moon day (Amavasya); leaves are used for the preparation of decoction offered to the pregnant lady during Punsavan Samskar
Ficus virens Aiton	Pilkhan	Leaves	Leaves dipped in the sacred utensil Kalash; after reverence, leaves are tied at the main gate of the house and stage of deities (mandapa)
Glycine max (L.) Merr. 'Kala bhatt'	Soyabean 'Kala bhatt'	Seed	Component of the seven grains (Saptanaja) used in Tantric tradition and reverence of ancestors
Gossypium hirsutum L.	Cotton	Seed fiber	Dried seed fibers are refined and rolled as thick thread called Bati, which are dipped in the brassica oil (Sarson oil) or clarified butter (Ghee) and lighted. These are termed as Deep. It is an essential part of every veneration
Hibiscus rosa-sinensis L.	Gudhal	Flower	Flowers are offered to Goddess deities
Hordeum vulgare L.	Jau	Whole plant, seed	Whole plant is venerated; plant fixed with cow dung at the main gate of the house on the occasion of Vasant Panchami; seeds used in sacrifice (Yajyan); reverence of ancestors; for donation on special occasions
Ipomoea batatas (L.) Lam.	Sakarkandi	Fruit	Used in the Chhat festival, Satyanarayan Vrat; consumed by devotees on the fasting days
Jasminum officinale L.	Chameli	Roots	Roots are harvested in the Pushya nakshtra invoked and wore as a pendant to become victorious
Lawsonia inermis L.	Mehandi	Leaves	Powder of leaves is applied on arms and foots of bride and bridegroom in different designs; offered to the Goddess Durga

Lens culinaris Medik.	Masur	Seed	To get rid of bad effects of the planet Mars (Mangal) over the bride and bridegroom. Seeds after reverence are donated along with red cloth
Lyonia ovalifolia (Wall.) Drude	Anyar	Twig	For the reverence of the ancestors (Pitra pooja) as a dental brush (Datoon)
Macrotyloma uniflorum (Lam.) Verdc.	Kulath	Seed	Component of the seven grains (Saptanaja)
Mangifera indica L.	Aam	Leaves, wood	Leaves are dipped in the sacred utensil Kalash; after reverence, leaves are tied at the main gate of the house and stage of deities (Mandapa); wood is used in sacrifice (Yajyan),
Mesua ferrea L	Nag keshar	Flower, buds	Used in Tantric tradition for prosperity
Mimusops elengi L.	Molshri, Keshav, Bakul	Roots	Daily at dawn, water is offered in the roots to get rid of bad effects of planet Mars (Mangala); people plant the herb in the premise of their home for auspicious effects
Musa paradisiaca L.	Kela	Whole plant, leaves, fruit	Whole plant used for the preparation of stage (Mandapa) of deities; plant venerated on Thursday (Guru Var) as a symbol of God Vishnu; fruit consumed by devotees on the fasting days
Myristica fragrans Houtt.	Jaiphal	Fruit	It is offered to Goddess Durga
Nardostachys jatamansi (D.Don) DC.	Masi	Rhizome	Used for fragrance in all ceremonies; also used in sacrifice (Yajyan)
Nelumbo nucifera Gaertn.	Kamal	Flower, stem, seeds	Flowers are offered to deities; a garland of seeds is used in the veneration of goddess Lakshmi; the flower is considered a symbol of creation and wealth and is associated with many deities as Lakshmi, Brahman etc.
Neolamarckia cadamba (Roxb.) Bosser	Kadamb	Whole tree, twig	Whole tree is considered sacred; twigs are placed in cow stable and it is believed that by doing so cattle are kept away from diseases
Nerium oleander L.	Kaner	Flower	Flowers are offered to deities; used in the oblation of the sacrifice (Yajyan)
Ocimum tenuiflorum L.	Tulsi	Whole plant, leaves	One of the sacred plants of Hindu tradition; leaves are used in the preparation of the food for deities (Prasada); leaves are used for the preparation of pious decoction Panchamrita; garland prepared from root and stem is revered; plant decorated as bride and symbol of God Vishnu (Shaligram shila) as bridegroom and marriage of both solemnized on Ekadashi of the Kartika month
Origanum vulgare L.	Badrinath Tulsi	Whole plant	Used for daily prayers in the shrine Badrinath
Oryza sativa L.	Dhan	Refined seeds	Used in veneration of deities; in reverence of ancestors; mixed with sandal paste (Chandan) and applied at the forehead (Akshta); cooked for preparation of food of deities (Prasada)
Pennisetum glaucum (L.) R.Br.	Bajra	Seed	Component of the seven grains (Saptanaja) used in Tantric tradition and reverence of ancestors
Phyllanthus emblica L.	Amla, Amalaki	Roots	Roots of tree are harvested in the Ashlesha nakshtra invoked and wore as a pendant on arms to clear out fear
Pinus roxburghii Sarg.	Cheer, Kulain	Twig, wood	For the preparation of the stage of deities (Dev mandapa); a large twig tree is fixed on the stage and decorated with different fruits and flowers as a symbol of deity; small stacks of wood are lit on the festival of Diwali
Piper betle L.	Pan	Leaves	Offered to deities as Tambula; used for the preparation of food for deities (Prasada)
Piper nigrum L.	Kali Mirch	Fruit	Used in Tantric tradition to get rid of bad spirits
Prunus cerasoides Buch.-Ham. ex D.Don	Panya	Twig, wood	For the veneration of deities (Dev pooja) and ancestors (Pitra pooja); venerated and burned on the festival of the Holi; wood is used in Yajyan
Punica granatum L.	Anar, Dadim	Whole plant, twig	The tree is planted in the Pushya Yoga considered auspicious; a flower is offered to the Goddess Dugra; in the Tantric tradition, pen is used for hymn writing
Putranjiva roxburghii Wall.	Putran jeeva	Fruit	Childless mothers in order to get a baby, wear necklace of fruits and worship it
Saccharum officinarum L.	Ganna	Stalk	Venerated on the occasion of Vijay Dashmi festival and other special occasions; on the festival of Chhat; used in Chholika ritual of marriage ceremony
Santalum album L.	Chandan	Wood	Red and yellow paste of wood is used in all rituals and applied at the forehead of deities and devotees; the paste is also mixed with water for the holy bath of the deities, bride and bridegroom
Saraca asoca (Roxb.) W.J.de Wilde	Ashok	Whole tree	Whole tree is considered holy and planted in the home premise for auspicious effects; invoked roots are placed in the lockers
Saussurea obvallata (DC.) Sch.Bip.	Brhmakamal	Flower	Flower is considered as a symbol of Goddess Nanda and venerated; garland of flowers is offered to shrine Kedarnath
Senegalia catechu (L.f.) P.J.H.Hurter & Mabb.	Khair, Kattha	Bole, wood	Articles of sacrifice (Yajyan) prepared from wood; used in the sacrifice; used in the veneration of planet Mars (Mangal)

Sesamum indicum L.	Til	Seed	Used in sacrifice (Yajyan); reverence of ancestors; for donation on special occasions
Setaria italica (L.) P.Beauv	Kangani, Kauni	Fruit	Component of the seven grains (Saptanaja) used in Tantric tradition and reverence of ancestors
Sida rhombifolia L.	Sahdevi	Roots	To get prosperity roots are wrapped in the piece of red cloth and invoked
Sorghum bicolor (L.) Moench	Jowar	Seed	Component of the seven grains (Saptanaja) used in Tantric tradition and reverence of ancestors
Spinacia oleracea L.	Palak	Whole plant	Offered to the Goddess Shakumbri during Navratra
Stephania glabra (Roxb.) Miers	Zimikand, Ginjyadu	Tuber	Used as alternative of animal sacrifice (Ashtha Bali)
Syzygium aromaticum (L.) Merr. & L.M.Perry	Laung	Bud	Used in veneration of deities; important component of the Tambula; specially used in Tantric tradition
Syzygium cumini (L.) Skeels	Jamun	Fruit	Fruit is offered to God Shiva; after invocation pendant of fruit is wore by devotees
Tabernaemontana divaricata R.Br. ex Roem. & Schult.	Tagar	Rhizome	Rhizome is used as oblation in the sacrifice (Yajyan)
Tamarindus indica L.	Imali	Fruit	In Tantric tradition, after the invocation, fruit is used for wealth and prosperity
Terminalia bellirica (Gaertn.) Roxb.	Baheda	Leaves, roots	Roots and leaves are used in Tantric tradition to acquire wealth
Thamnocalamus spathiflorus (Trin.) Munro	Ringal	Bole/stalk	For preparation of articles of deities as baskets etc.; an article Chhawda used as a plate in the reverence of ghost and similar deities (Tamsi Pooja); an umbrella is prepared in the reverence of Goddess Nanda
Tinospora cordifolia (Willd.) Hook.f. & Thomson	Giloy	Stem, leaves	Stem is offered to Goddess Durga; leaves are used for the preparation of decoction offered to the pregnant lady during Punsavan Samskar
Trapa natans L.	Singhada	Fruit	Used in the occasion of Vijay Dashmi festival; used in the fast of Ekadashi day; different cuisines of flour consumed by devotees during fast
Tripidium bengalense (Retz.) H.Scholz	Sarkanda	Leaves	Used in the preparation of stage (Mandapa) on the auspicious functions; plant is also associated with the birth story of God Kartikeya
Triticum aestivum L.	Gehun	Milled seed (flour)	For the preparation of food (Prasada) of deities; earlier it was considered as food of elites
Urtica dioica L.	Kandali, Bichchhu Ghas	Twig	Used in Tantric tradition to get rid of bad spirits
Verbascum thapsus L.	Ekulu Veer	Whole plant	Whole plant is revered in the Tantric tradition to get rid of bad spirits
Vigna mungo (L.) Hepper	Urad	Seeds	Used in reverence of ancestors, donated in the offering of planet Saturn (Shani); used as an alternative to animal sacrifice (Makh Bali)
Vigna radiata (L.) R.Wilczek	Mung	Seed	To get rid of bad effects of the planet Mercury (Budha) seeds are donated
Vitex negundo L.	Nirgundi	Twigs, roots	Twigs and roots are used in Tantric tradition; it is specially used in Khechari Vidhya
Zanthoxylum armatum DC.	Timur	Bole/salk	Bole is used as a symbol of deities (Bhairava, Narsimbha, Nag, Sidhnath, etc.); saints (Sadhu) carry it along with them
Ziziphus mauritiana Lam.	Ber	Fruit	Fruit is offered to God Shiva

Table 2. Wood of plants used in sacrifice as Samvidha

Plant name (Hindu tradition)	Scientific name
Palas, Dhak	*Butea monosperma* (Lam.) Kuntze
Khair, Kattha, Khadira	*Senegalia catechu* (L.f.) P.J.H.Hurter & Mabb.
Pilkhan, Pakad, Plaksha	*Ficus virens* Aiton
Peepal	*Ficus religiosa* L.
Gular, Audumbar	*Ficus racemosa* L.
Bargad, Nyagrodha	*Ficus benghalensis* L.
Shami	*Prosopis cineraria* (L.) Druce
Chandan	*Santalum album* L.
Devdar, Deodara	*Cedrus deodara* (Roxb. ex D.Don) G.Don
Shal, Sal	*Shorea robusta* C.F.Gaertn.
Bilva, Bel	*Aegle marmelos* (L.) Corrêa
Chir, Sarala	*Pinus roxburghii* Sarg.
Vattha, Vattakanni	*Macaranga peltata* (Roxb.) Müll.Arg.

Table 3. Plant-based component of oblation (Havishya) of sacrifice (Yajyan)

Plant name (Hindu tradition)	Scientific name	Part
Til	*Sesamum indicum* L.	Seed
Jau	*Hordeum vulgare* L.	Seed
Dhan	*Oryza sativa* L.	Seed (refined)
Ganna	*Saccharum officinarum* L.	Sugar

Table 4. Plant parts used for the fragrance during the sacrifice (Yajyan)

Plant name (Hindu tradition)	Scientific name	Part
Jatamansi	*Nardostachys jatamansi* (D.Don) DC.	Rhizome
Kaner	*Nerium oleander* L.	Flower
Tagar	*Tabernaemontana divaricate* R.Br. ex Roem. & Schult.	Rhizome
Karpur	*Cinnamomum camphora* (L.) J.Presl	Latex (wood)
Guggal	*Commiphora wightii* (Arn.) Bhandari	Resin (wood)
Agar, Agaru	*Aquilaria malaccensis* Lam.	Resin (wood)

Table 5. Plant-based component as alternative (Makh Bali and Ashth Bali) of animal slaying

Plant name (Hindu tradition)	Scientific name	Part
Urad	*Vigna mungo* (L.) Hepper	Seed
Arabi, Papad	*Colocasia esculenta* (L.) Schott	Rhizome
Petha	*Benincasa hispida* (Thunb.) Cogn.	Fruit
Kaddu	*Cucurbita pepo* L.	Fruit
Zimikand	*Stephania glabra* (Roxb.) Miers	Tuber
Nariyal	*Cocos nucifera* L.	Fruit
Bada Nimbu	*Citrus pseudolimon* Tanaka	Fruit
Genthi	*Dioscorea bulbifera* L.	Rhizome, Fruit
Tedu	*Dioscorea deltoidea* Wall. ex Griseb.	Rhizome, Fruit

Table 6. List of Panch Pallav (five sacred leaves)

Plant name (Hindu tradition)	Scientific name
Peepal	*Ficus religiosa* L.
Aam	*Mangifera indica* L.
Bargad, Vat	*Ficus benghalensis* L.
Gular	*Ficus racemosa* L.
Pilkhan, Pakad	*Ficus virens* Aiton

Table 7. Panch Mewa (five sacred dry fruits)

Plant name (Hindu tradition)	Scientific name
Akhrot	*Juglans regia* L.
Anjir	*Ficus carica* L.
Nariyal	*Cocos nucifera* L.
Makhane	*Euryale ferox* Salisb.
Khajur	*Phoenix sylvestris* (L.) Roxb.

Table 8. Seven grains (*Saptanaja*) offered to the deity

Plant name (Hindu tradition)	Scientific name
Group 1	
Gehun	*Triticum aestivum* L.
Jau	*Hordeum vulgare* L.
Dhan	*Oryza sativa* L.
Urad	*Vigna mungo* (L.) Hepper
Kulath	*Macrotyloma uniflorum* (Lam.) Verdc.
Jowar	*Sorghum bicolor* (L.) Moench
Bajra	*Pennisetum glaucum* (L.) R.Br.
Group 2	
Gehun	*Triticum aestivum* L.
Jau	*Hordeum vulgare* L.
Dhan	*Oryza sativa* L.
Urad	*Vigna mungo* (L.) Hepper
Mandua	*Eleusine coracana* (L.) Gaertn.
Jhangora, Sanva	*Echinochloa frumentacea* Link
Soyabean'Kala bhat'	*Glycine max* (L.) Merr. 'Kala bhatt'
Group 3	
Gehun	*Triticum aestivum* L.
Jau	*Hordeum vulgare* L.
Dhan	*Oryza sativa* L.
Til	*Sesamum indicum* L.
Kangani	*Setaria italica* (L.) P.Beauv
Chana	*Cicer arietinum* L.
Sanva	*Echinochloa frumentacea* Link

Table 9. Plant used in *Sarvoshadhi*

Plant name (Hindu tradition)	Scientific name
Mura	*Selinum candollei* Edgew
Jatamansi	*Nardostachys jatamansi* (D.Don) DC.
Vach	*Acorus calamus* L.
Kushth, Kuth	*Dolomiaea costus* (Falc.) Kasana & A.K.Pandey
Shilajeet	Dried exudates of certain plants as *Euphorbia royleana* Boiss., *Trifolium repens* L. *Barbula* sp., *Fissidens* sp., *Minium* sp., *Thuidium* sp. etc. on rocks
Haldi	*Curcuma longa* L.
Daru Haldi	*Berberis aristata* DC.
Sathi, Punarnva	*Boerhavia diffusa* L.
Champaka, Champa	*Magnolia champaca* (L.) Baill. ex Pierre
Musta	*Cyperus rotundus* L.

Navgraha (nine planets)

For the worship of the nine planets, nine plants are venerated. It is believed that nine planets influence an individual's psychological and physiological activity. It depends on the horoscope of a person. To get rid of the negative effects of any planet, people worship the plant designated to the planet. Detail of the planet and its respective plant is provided in Table 12.

Table 10. Component of the Panchamrita (five elixirs)

Components	Name (Hindu tradition)
Milk	Dugdh, Doodh
Curd	Dahi
Clarified butter	Ghee
Honey or Sugar	Shahad or shakkar
Tulasi (*Ocimum tenuiflorum* L.) leaves	Tulasi Patra

Table 11. Component of the Panchagavya (five pious from cow)

Components	Name (Hindu tradition)
Milk	Dugdh, Doodh
Curd	Dahi
Clarified butter	Ghee
Cow urine	Gau Mutra
Fresh cow dung	Gaubar

Table 12. Planets as per Hindu tradition and their respective plant

Planet name (Hindu tradition)	English name	Plant (Hindu tradition)	Plant (scientific name)
Surya	Sun	Arka, Mandar or Madar	*Calotropis gigantea* (L.) W.T.Aiton
Chandra, Soma	Moon	Palas, Dhak	*Butea monosperma* (Lam.) Kuntze
Mangal	Mars	Khair, Kattha	*Senegalia catechu* (L.f.) P.J.H.Hurter & Mabb.
Budha	Mercury	Apamarga, Chirchida	*Achyranthes aspera* L.
Brhaspati, Guru	Jupiter	Peepal	*Ficus religiosa* L.
Shukra	Venus	Gular	*Ficus racemosa* L.
Shani	Saturn	Shami	*Prosopis cineraria* (L.) Druce
Rahu		Doob	*Cynodon dactylon* (L.) Pers.
Ketu		Kusha	*Desmostachya bipinnata* (L.) Stapf

Table 13. Plant used in the Tambula

Plant name (Hindu tradition)	Scientific name	Part
Supari, Pungiphalam	*Areca catechu* L.	Fruit
Ilayachi (Chhoti), Ela	*Elettaria cardamomum* (L.) Maton	Fruit
Laung, Lavang	*Syzygium aromaticum* (L.) Merr. & L.M.Perry	Bud
Pan, Nagvalli	*Piper betle* L.	Leaves

Tambula

It is the combination of the plant parts mentioned in Table 13. Plants used in the Tambula (either in combination or individually) are offered to the deities to get rid of the bad odor of the mouth. It is offered after offering food (Naivedhyam) to the deity.

Documentation of the plant species used in different Hindu rituals is done in the present article. It is an attempt to document this traditional heritage of India so that it can be passed to the upcoming generations. In the globalized and techno-centric world, hoarders of traditional knowledge are very few. Information about the culture and ethnic practices of any locality is usually limited to certain people with ages older than 50 years. The younger generation is not enthusiastic about traditional knowledge; consequently, this heritage is threatened. Different components of nature such as plant parts or products, soil, animal products, water, and different minerals were used by our ancestors to perform rituals so that they could stay in touch with nature. Due to urbanization and deforestation, most young people have not encountered those plants in natural conditions, which are used in different rituals. For the completion of the rituals, plant parts or products are available in packets. People use these packed products for the worship of deities and ceremonies. Hence, the connection between people the nature is getting lost. Therefore, it is necessary to sensitize the younger generation toward our traditional heritage and its scientific utility.

ACKNOWLEDGEMENTS

The author is thankful to Shri Bhagwati Prasad Bhatt 'Shastri', Shri Dev Prakash Semwal, Shri Janardhan Prasad Semwal, and Shri Jagdamba Prasad Purohit for their inspiration and guidance. The author also acknowledges the effort of the priests, old persons, and other traditional knowledge hoarders to practice and conserve the old-age tradition and culture.

REFERENCES

Acharya PSS, Sharma BD. 2018a. Rigved Samhita, Vol. I. Yug Nirman Vistar Trust, Gayatri Tapobhumi Mathura, India.

Acharya PSS, Sharma BD. 2018b. Rigved Samhita, Vol. II, Yug Nirman Vistar Trust, Gayatri Tapobhumi Mathura, India.

Acharya PSS, Sharma BD. 2018c. Rigved Samhita, Vol. IV. Yug Nirman Vistar Trust, Gayatri Tapobhumi Mathura, India.

Acharya PSS, Sharma BD. 2018d. RigvedSamhita, Vol. III. Yug Nirman Vistar Trust, Gayatri Tapobhumi Mathura, India.
Acharya PSS. 2014. Karma Kand Bhaskar. Yug Nirman Vistar Trust, Gayatri Tapobhumi Mathura, India.
Agrawala VS. 1952. Ancient Indian flora in the Ashtadhyayi of Panini. Palaeobotanist 1: 61-65.
Amirthalingam M. 2013. Plant & Animal Diversity in Valmiki's Ramayana. Environmental Education Centre, Chennai.
Arya A. 2007. Medicinal plants mentioned in Atharvaveda. In: Daniel M, Arya A, Raole VM (eds). Herbal Technology: Recent Trends and Progress, (Natural History Book Service). Scientific Publishers, India.
Avasthi ATD. 2020. Pooja Bhaskar. B.S Parminder Prakashan, India.
Balkrishna A, Mishra RK, Srivastava A, Joshi B, Marde R, Prajapati UB. 2019. Ancient Indian rishi's (Sages) knowledge of botany and medicinal plants since Vedic period was much older than the period of Theophrastus, A case study-who was the actual father of botany? Intl J Unani Integr Med 3 (3): 40-44.
Chaturvedi PJP. 2015. Brihad Pooja Bhaskar. Randhir Prakashan Haridwar India.
Deb B. 1955. The flora in Kālidāsa's literature: A note. Annals of the Bhandarkar Oriental Research Institute 36 (3/4): 352-357.
Dhiman AK. 2003. Sacred Plants and Their Medicinal Uses. Daya Publishing House Delhi, India.
Dixit PR. 2019. Dus Mahavidya - Tantra Mahashastra. Deep Publications, India.
Drabu VN. 1990. Śaivāgamas: A Study in the Socio-economic Ideas and Institutions of Kashmir (200 BC to AD 700). Indus Publishing, India.
Gaur AK. 2015. Anushthan Prakash. Rupesh Thakur Prasad Prakshan, Varanasi, India.
Gaur VS, Shastri MM, Shastri RN. 2018. SamdhyopasanVidhi aur Tarpan evam balivaishvdev Vidhi. Gita Press Gorakhpur, India.
Girdharwal S. 2006. Shodashi Mahavidya (Tripurasundari Sri Yantra Pooja Vidhi). Astha Prakashan Mandir, India.
Khemka RS. 1993. Nitya Karm Pooja Prakash. Geeta Presh Gorakhpur, India.
Mishra P. 2001. Sampuran Havan Paddati. Randhir Prakashan, Delhi.
Narayan K. 2012. Rudryamaltantroktam Shri Devirahsayam. Chowkhamba Surbharati Prakashan, India.
Pandey PJ, Mishra PL, Shastri PR. 2011. Antyakrma Shraddhprakash. Geeta Presh Gorakhpur, India.
Radhakrishnan S. 2018. The Principal Upnisads. Harper Collins Publishers, Noida India. (28th impression, first published in 1953).
Sharma HD.2008. Vashishthi Hawan Paddhati. Khemraj Shrikrishnadas Publisher, Mumbai, India.
Sharma S.1995. Karmakand Sangrah. Shri Krishna Jyotish Bhawan, Kaithal, Haryana.
Sharma VM. 1985. Pooja Bhaskar. Vishal Karyalay, Garhwal, India.
Sharma VM. 1990. Pooja Bhaskar. Pankaj Prakashan Mathura, India.
Sharma VM. 1991. Karma Kand Bhaskar. Pankaj Prakashan Mathura, India.
Shastri JP. 1999. Pooja Bhaskar. B.S. Printers, Delhi, India.
Shastri RN. 2016. Shri Durga Shaptshati. Geeta Presh Gorakhpur, India.
Srimali RK. 2015. Dus Mahavidya. Diamond Pocket Books, India.
Tripathi RK. 2019. Herbs and plants in Vedic literature: A modern perspective. Intl J Manag Appl Sci 5 (9): 121-124.
Varma D. 2015. Medicinal plants used during the period of Ramayana. Intl J Exch Knowl 2 (1): 41-44.
Verma R, Bodha B, Kumavat S. 2009. Sulabh Samagri Durlabh Prayog. Hansha Publisher, Jaipur India.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 5, Number 2, November 2022 E-ISSN: 2580-4510
Pages: 102-119 DOI: 10.13057/asianjethnobiol/y050204

Review: Ethnomedicinal plants used for wound healing and dermatological problem in the North-Eastern Hill Region of India

GUNJAN DAS[1,♥], KIERUTHEILE THOU[1], PRIYA MONDAL[2], SYED MUSTHAPA MEERAN[2]
[1]Department of Veterinary Medicine, College of Veterinary Sciences and A.H (Jalukie). Peren-797110, Nagaland, India.
Tel./fax.: +91-9436198779, ♥email: dasgunjan@gmail.com
[2]Department of Biochemistry, CSIR-Central Food Technological Research Institute. Mysore-570020, India

Manuscript received: 26 April 2022. Revision accepted: 21 August 2022.

Abstract. *Das G, Thou K, Mondal P, Meeran SM. 2022. Review: Ethnomedicinal plants used for wound healing and dermatological problem in the North-Eastern Hill Region of India. Asian J Ethnobiol 5: 102-119.* Wound healing is a complex process that facilitates tissue cohesion and homeostasis renewal. Medicinal plants have several bioactive compounds and play a principal role in healing and curing human and animal diseases. In our review, we collected ethnobotanical information mostly from Nagaland, a North-Eastern state of India, from various ethnic groups through personal communication, articles, surveys, and sources. In this study, we selected 26 plant species belonging to 20 families categorized as herbs (15 species), shrubs (5 species), trees (4 species), and climbers (2 species) with scientifically demonstrated medicinal properties or reported from ethnic groups on wound healing, dermatological problem, other numerous diseases and disorders relating to the urinary system, inflammation, tumors, diabetes, diarrhea, gastritis, scabies, skin sores, animal/insect bites, parasitic related problems, and rheumatism. They have been compiled and reviewed. Medicinal plants are considered efficacious adjuvants or alternatives to conventional therapies to treat various diseases, and the use of medicinal plants and their products to cure different ailments was reported and recorded. Our review will help create awareness about using medicinal plants and alternative medicine to ameliorate dermatological problems and treat various diseases in humans and animals.

Keywords: Dermatological problems, ethnomedicine, indigenous traditional knowledge, Naga Tribes, wound healing

Abbreviations: AGS: Aged garlic solution; AMR: antimicrobial resistance; cAMP: cyclic adenosine monophosphate; ECM: Extracellular matrix; FGF: Fibroblast growth factors; IGF-1: Insulin-like growth factor-1; IL: Interleukin; ITK: Indigenous traditional knowledge; LDL: Low-density lipoprotein; MDR: multiple drug resistance; NE: North eastern; PBS: Phosphate-buffered saline; PDGF: Platelet-derived growth factor; PFFA: *Paederia foetida* flower absolute; TGF-β: Transforming growth factor beta; TNF-α: Tumour Necrosis Factor-alpha; VEGF: Vascular endothelial growth factor

INTRODUCTION

Nagaland is a state situated in the North-Eastern region of India, bordering the Indian states of Arunachal Pradesh to the north, Assam to the west, Manipur to the south, and the part of Myanmar to the east. The state of Nagaland has a section of 16.579 sq km. and it lies between 25°10'N to 27°4'N longitude and 93°15'E to 95°6'E longitude. The state is generally mountainous except for those areas bordering Assam. Nagaland encompasses a monsoonal climate. Nagaland is presented with a favorable ecological, atmospheric condition-rich repository of biodiversity and medicinal plants. The local tribes use plants that have medicinal properties and values for healing, curing many clinical issues in general and dermatological problems in specific. Medicinal plants became a part of the socio-cultural heritage. These practices have evolved over a protracted period with tests and errors by some ethnic groups and passed on to new generations. World Health Organization (WHO) (2008) defines traditional medicine as 'the health practices, approaches, knowledge, and beliefs incorporating plant, animal and mineral-based medicines, spiritual therapies, manual techniques, and exercises, applied singularly or in combination to treat, diagnose and prevent illnesses or maintain well-being. The knowledge of this traditional healing system is as old as humanity and dates back to the start of civilization. Ethno-botanical studies have led to the documentation of conventional and non-conventional medicinal plants utilized by tribals for meeting their multifarious requirements. The tribal people and ethnic races throughout the globe have developed their extensive knowledge of medicinal plants for treating illness (Bhuyan et al. 2014). The state also experiences abundant biological resources and traditional medicinal knowledge, which is advantageous for tribal people (Zhasa et al. 2015).

Despite the bewildering diversity, the ethnicity of Nagaland is blended by different tribes, and the sub-tribe group dates back to the classical era. Nagaland has 16 recognized tribes, and each community has a unique and rich cultural heritage. The social structure, customs, festivals, and beliefs of all communities are different from one another. However, despite the differences, they have been living harmoniously in the state for centuries, and ethnic communities have developed a vibrant stage of

cultural mobility. The Nagas, the people of Nagaland, have ordinarily built their villages on mountain tops where the climate is healthier, pleasant, and self-contained. The villages, fields, and forests provide a wide range of food and spices, raw materials, and ethnomedicine for all kinds of needs of the people. Nagas residing in villages live an elementary life and are mostly farmers, as they yield most of the food and many other essential commodities by themselves. They do not have access to modern medicine due to unavailability and cost, which is one of the main reasons they opt for and practice traditional medicine using plants having medicinal properties. Moreover, it is safe to use, efficacious and economical. Indigenous remedies are gaining recognition among the people of both urban and rural areas. Information from ethnic groups or indigenous traditional medicine has played a vital role in the discovery of novel products from plants. The practice of ethnopharmacology is the pioneer of contemporary medicine.

Medicinal plants have bioactive compounds used for curing various human diseases and play an essential function in healing (Wadood et al. 2013; Putra et al. 2020; Nugroho et al. 2020). The medicinal plant bioactive has a greater role in altering the cell proliferation in wound healing activity (Lordani et al. 2018). Medicinal plants enriched with secondary metabolites harbor potential endophytic microbes involved in various disease pathology. These plants synthesize a diverse array of biologically active compounds essential to survive and flourish within the natural environment, including protective functions concerning abiotic stresses derived from temperature, water, mineral nutrient supply, and bug pests (Egamberdieva et al. 2017). Phytotherapeutic agents are primarily used for cutaneous wound healing and dermatological problems. Medicinal plants can inhibit the expansion of a good range of pathogenic microorganisms because of essential oils (Akhtar et al. 2014). Phytochemicals present in plants are liable for preventing disease and promoting health (Saxena et al. 2013). Changes in temperature associated with climate change are seriously affecting plant architecture, phytochemical composition, flowering, fruiting, and in situ competition with other species as India's climate is chiefly controlled by an annual monsoon, and it appears to be experiencing increasingly severe year after year (Kumar et al. 2017). Since not only are allopathic medicines accessible to tribal populations but their chronic side effects of indiscriminate consumption are well known (Kumarasamayraja et al. 2012). The problem became a spotlight for researchers to resolve the wound infection by using the plant as an alternate solution. Plant products may potentially heal wounds because they promote the repair mechanisms in an exceedingly natural way (Farah et al. 2018).

Wounds types and healing process

A wound is an injury or disruption to the anatomical structure especially epithelial integrity of the skin, even extended in-depth to subcutaneous tissue and other body parts such as ligaments, muscles, blood vessels, nerves, and bone (Robson et al. 2001). According to the healing time frame, wounds are categorized as acute and chronic. Acute wounds can self-repair by following a systematic healing process that restores the anatomical and functional structure. The damage of soft tissue or bone fractures is considered under acute wounds. Usually, healing of acute wounds requires 5 to 10 days or a maximum of 30 days (Velnar et al. 2009). In contrast, chronic wounds fail to process self-repair mechanisms due to various factors such as infection, tissue hypoxia, necrosis, and a surplus of inflammatory cytokines. Chronic wounds require prolonging the time in different phases of the healing process. Among different stages of the wound healing process, prolonged inflammation produces a cascade of tissue which perpetuates a non-healing state, therefore, chronic wounds frequently relapse (Degreef 1998; Robson et al. 2001). Besides a complicated wound is another type of wound that combines an infection and a tissue defect (Bischoff et al. 1999). Infection is always a persistent threat to any wound and can occur due to exposure to different contaminants. Therefore, based on the degree of contamination, wounds are further categorized into three groups: (i) aseptic wounds (bone and joint operations); (ii) contaminated wounds (abdominal and lung operations); and (iii) septic wounds (sores, bowel operations) (Broughton et al. 2006). Wound healing is an intricate process continued with numerous cellular events. Hemostasis, inflammation, proliferation, and dermal remodeling are four distinct overlapping phases of wound healing. Hemostasis is the first stage after injury where vasoconstriction happens, and platelets are activated when interacting with extracellular matrix proteins (ECM) (e.g., fibronectin, collagen, and von Willebrand factor). These ECM proteins enhance cellular migration and interactions with the matrix supporting framework. After activation, platelets discharge some soluble intermediaries such as growth factors (TGF-β, PDGF, IGF-1, VEGF), cAMP, and adhesive glycoproteins, promoting adhesion and aggression. Then, clotting factors are released and form a provisional matrix, where aggregated platelets are trapped and form the bulk of the clot (Gailit et al. 1994). In addition, some clotting enzymes, inactively present in these matrices, are activated and promote the clotting process. In the next phase, inflammation occurs in the first 24 hours, lasts up to 2 weeks in the acute wound, and much longer in a chronic wound. Different immune cells, such as neutrophils, monocytes, and macrophages, release pro-inflammatory cytokines, such as IL-1, IL-6, IL-8, and TNF-α, to clean the wound infection by removing bacteria and denatured matrix components. They also release some growth factors such as PDGF, TGF-β, TGF-α, IGF-1, and FGF to recruit and activate the fibroblasts and epithelial cells to initiate the next phase of proliferation and synthesis of new ECM (Fitridge and Thompson 2011). These growth factors stimulate proliferation, chemotaxis, and collagenase expression of fibroblast. After migration, fibroblast alters their morphology, settles down, and replaces the provisional fibrin matrix with a new matrix of collagen fibers, proteoglycans, and fibronectin. Similarly, injured vasculature also might be replaced by the maintained tissue. After forming a new matrix, epithelialization occurs

where epithelial cells detach and alter their internal structure, migrate, proliferate and differentiate over the granulation tissue to close the wound surface (O'Toole 2001). Matrix remodeling is the final phase of the healing process where granulation tissue matures into scar and tissue tensile strength is enhanced. Simultaneously, the density of fibroblast and capillary decreases, and the scar is replaced by ECM, similar to normal skin, as depicted in Figure 1. ECM remodeling is the result of the balanced, regulated activity of proteases.

Propagating the knowledge of ethnomedicine in North-Eastern hill region

The North-Eastern states of the Republic of India comprise eight states: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. It is the state of an outsized range of tribes and represents one of the diverse hotspots of the globe, with the richest plant diversity in India. The tribes of North East India are categorized into completely different ethnic communities. Social folks are the ecosystem folks that live in harmony with nature and maintain an in-depth link between man and the atmosphere. Ethnic groups possess rich knowledge concerning diagnosing and treating significant to minor diseases and are typically specialists in the art of ancient medicine in their community. They conjointly perform varied sorcerous rites and worship for the treatment of diseases. Their knowledge is passed on from generation to generation by oral tradition and, far from the traditional knowledge, has been an unbroken secret to the outside world (Debbarma et al. 2017). In this present era, modern drugs are taking a critical role in treating and curing diseases; however, several tribal communities lack a physiological condition care system. Most tribal economies are engaged in subsistence agriculture and have developed great information on using plants and plant products to cure varied ailments. In addition, the population encompasses a deep belief in their native folklore medicine for remedies (Majumdar and Datta 2007).

In light of the above, our main aim should be to help propagate Indigenous traditional knowledge (ITK) developed by tribals to validate and treat various ailments related to humans and animals. Several of our ethnic groups from NE states are already practicing ethnomedicine and ethnoveterinary practices knowingly or unknowingly. However, the knowledge of these practices must reach the end-user for their benefit. Moreover, multiple drug resistance (MDR) and antimicrobial resistance (AMR) are global concerns. At this juncture, alternative medicinal approaches have been taken up globally as mother nature has endowed the NE states with an abundance of herbal flora, a blessing in disguise.

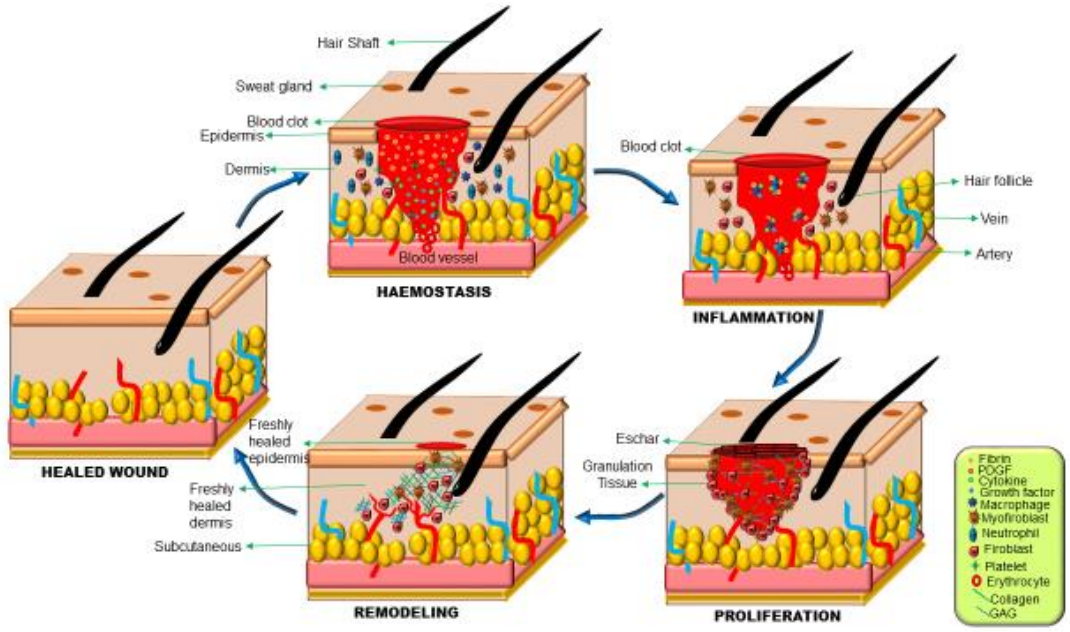


Figure 1. The processes involved in wound healing. The mechanism and stages of the wound healing process. This process will start with hemostasis, where aggregated platelet is trapped and form the bulk of the clot to prevent blood loss. Next, activated platelets release growth factors to promote adhesion and aggression, thereby a provisional matrix is formed. Then during inflammation, different immune cells release pro-inflammatory cytokines for cleaning the wound infection by removing bacteria and denatured matrix components. They also release some growth factors FGF to recruit and activate the fibroblasts and epithelial cells to initiate subsequent phases of proliferation and synthesis of new ECM. After migration, fibroblast alters their morphology, settling down and replacing the provisional fibrin matrix with a new matrix. In the new matrix, epithelial cells detach and change their internal structure, then migrate, proliferate and differentiate over the granulation tissue to close the wound surface. Matrix remodeling is the final phase of the healing process where granulation tissue matures into the scar and the density of fibroblast and capillary decreases. Finally, the scar is replaced by ECM, similar to normal skin.

Commonly used herbs of Nagaland against wound and dermatological problems

This review comprehensively presents the compilation of medicinal plants available in the NE region and their traditional uses for various wound healing activities and dermatological issues. These native medicinal plants are found throughout Nagaland. However, their availability and efficacy vary from season to season and at different altitudes of the region. The plant species' botanical names are organized alphabetically, including the authority and family names followed by their common (local dialect) and English names with their known traditional uses (Figure 2; Table 1).

Ageratum conyzoides *(L.) L.; Asteraceae (Langtampuihei-Zeliang; Pru-Chakesang; Nhasa-Angami; Goatweed/Whiteweed-English)*

The *A. conyzoides* is an erect, herbaceous annual herb. In a few nations, the species is considered a weed, difficult to control its growth. Seeds are positively photoelastic, and viability is regularly lost within 12 months (Marks and Nwachuku 1986; Ladeira et al. 1987). The *A. conyzoides* is extensively applied in traditional medicinal drugs to use diverse cultures worldwide, even though applications range through the region. Locals use this plant to treat pneumonia; however, the most common use is to cure wounds and burns (Ming 1999). Leaf paste is applied to cuts and wounds (Debbarma et al. 2017). The *A. conyzoides* is a local remedy for external ailments like craw-craw, boils, wounds, and leprosy and internally for uterine troubles, purulent ophthalmia, and gynecological diseases. Plant constituents like saponins, phenolics, and flavonoids are ascribed to expedite the stages of wound healing (Dash and Murthy 2011). Leaf paste to cuts and wounds as hemostatic by the Chakesang Tribe of Nagaland (Nelia and Limasenla 2020). The traditional groups have been known to use this species as a bactericide, antidysenteric, and antilithic. The aqueous extract of this plant is used as a bactericide and used to treat fever, rheumatism, headache, cold, and the soup of the whole plant is used to stop dysentery (Ming 1999). Aqueous extract of the entire plant, verified effective clinical control of arthrosis, reporting a decrease in pain and inflammation or improvement in articulation mobility after a week of treatment (Matos 1988). The use of this species in the traditional medicinal drug is significant in Nagaland. According to the ethnic group and older adults of Nagaland, it was reported that the mashed leaves are applied to cuts and injuries by the Angami and Zeliang Tribes of Nagaland (pers. obs.).

Allium sativum *L.; Alliaceae (Naharu-Assamese; Simria-Zeliang; Chiimeria-Angami; Garlic-English)*

The *A. sativum* is commonly used as a culinary spice and is also a known antioxidant. Many tribals cultivate *A. sativum* for their culinary needs and commercial purposes. The *A. sativum* derivatives are often used for antibacterial, antifungal activity, anti-inflammatory, antiparasitic activity, and hypoglycemic properties and have been shown to have a strong anticancer activity (Sidik et al. 2006). It caused an increase in fibrinolytic activity, inhibited platelet aggregation, and lowered cholesterol. It has been used historically to enhance circulation, fit stress and fatigue, and stimulate immune function. Wounds treated with garlic extract and honey significantly accelerate wound healing (Sidik et al. 2006). The ethnic group of the Zeliang Tribe uses root bulbs of garlic, finely crushed and heated with mustard oil to relieve sore throat and the common cold (pers. obs.). It has been shown that sulfur compounds (thiosulfinates) appear to be the active components in the root bulb of the garlic plant. Some studies have suggested that thiosulfinates may be important in preventing bacterial and fungal infections during the wound healing process. Furthermore, it has been demonstrated that sulfur compounds (allicin) stimulate the proliferation of chondrocytes (Santiago et al. 2020). Some findings show that aged garlic solution (AGS) can influence multiple aspects of wound healing and play a vital role in stimulating different cascades of wound healing and angiogenesis (Ejaz et al. 2009). Among various preparations of garlic supplements, it was found that a particular aged garlic solution (AGS) has given sound scientific experiments in wound healing (Ide et al. 1997; Ide and Lau 1999a,b; Ryu et al. 2001).

Aloe vera *(L.) Burm. f.; Asphodelaceae (Alovira-Lotha)*

The *A. vera* treats burns, ulcers, and surgical wounds. The *A. vera* plant possesses astringent, hemostatic, antidiabetic, antiulcer, antiseptic, antibacterial, anti-inflammatory, antioxidant, anticancer, antidiarrhoeal, and wound healing properties (Saini et al. 2016). The *A. vera* has been used for ages and includes the major ingredient in various commercial skin and wound-care products (Dorai 2012). The mucilage content in this plant's leaves, also known as aloe gel, is used for various cosmetics and clinical applications (Hashemi et al. 2015). The *A. vera* leaves pulp was found to have a better and quicker wound healing effect than the standard drug Povidone Iodine ointment (5% w/w) in the excision wound model (Purohit et al. 2012). Fresh aloe leaf is crushed and implemented in the burnt region to get a cooling effect (Jamir et al. 1999). The Chakesang Tribe uses succulent stem juice, which is raw for gastritis and is also applied as a moisturizer on pores and skin dryness (Bharali et al. 2017). According to an ethnic group of Zeliang, Angami, Sumi, Konyak, Lotha, and Rengma Tribes, they use the fresh stem to apply on skin burns, acne, and skin ulcers for quick healing. The raw stem of *A. vera* is also consumed directly to reduce stomach inflammation and expel parasitic worms (pers. obs.). Leaves are used in stomach trouble, purgative, pulp in menstrual disorders, dried juice in constipation, and root in colic disorders (Tripathi et al. 2017). Studies have revealed that treatment with *A. vera* gel accelerated the lesion healing (Liu et al. 2006; Tarameshloo et al. 2012). The *A. vera* has been used for therapeutic purposes by diverse cultures because of its cicatrizing effects (Grace et al. 2008).

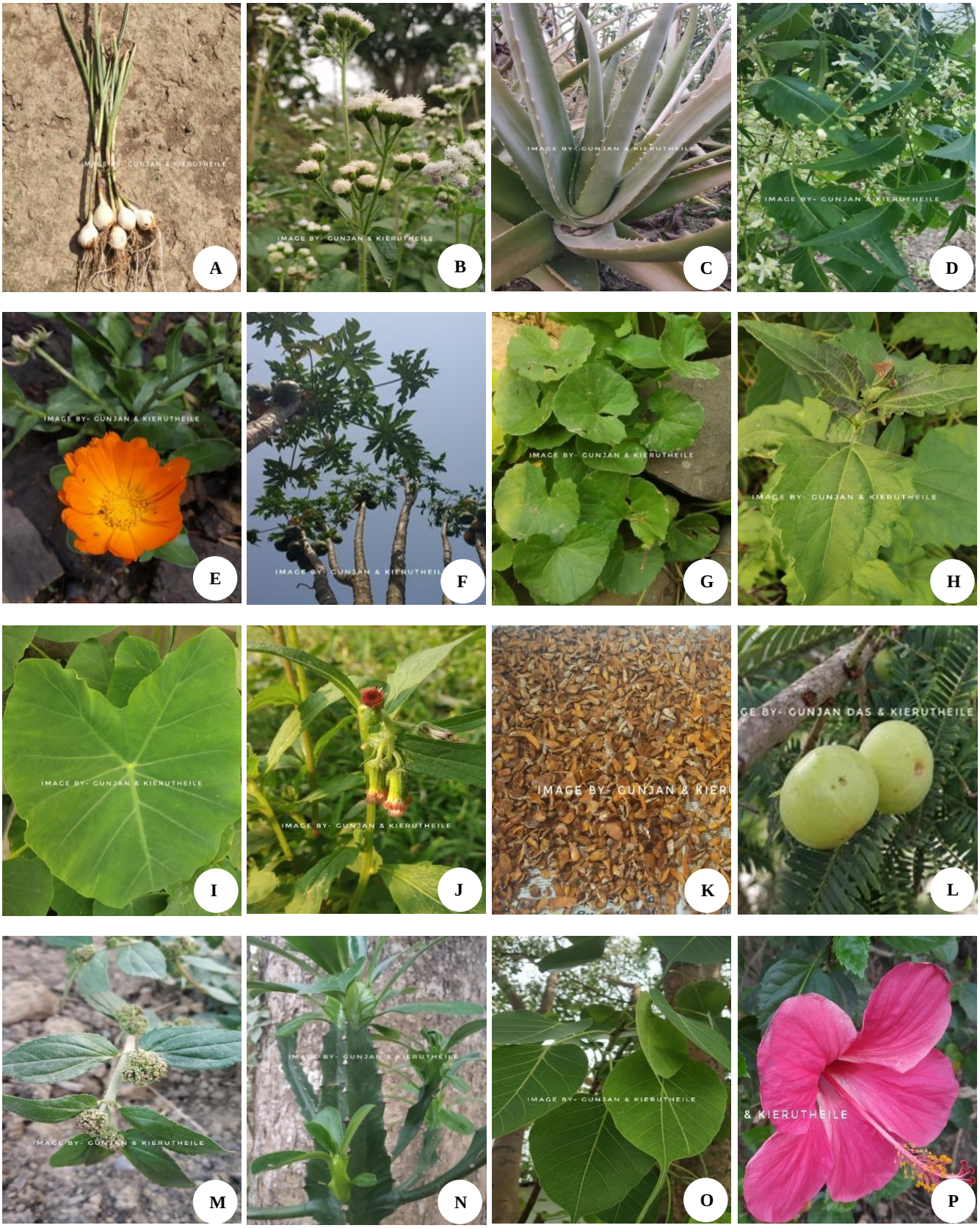

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P

Figure 2. A. *Ageratum conyzoides*, B. *Allium sativum*, C. *Aloe vera*, D. *Azadirachta indica*, *E. Calendula officinalis*, *F. Carica papaya;* G. *Centella asiatica;* H. *Chromolaena odorata;* I. *Colocasia esculenta;* J. *Crassocephalum crepidioides;* K. *Curcuma longa;* L. *Emblica officinalis;* M. *Euphorbia hirta;* N. *Euphorbia neriifolia;* O. *Ficus religiosa;* P. *Hibiscus rosa-sinensis;* Q. *Kalanchoe pinnata;* R. *Lantana camara;* S. *Leucas aspera;* T. *Mikania micrantha;* U. *Mimosa pudica;* V. *Oxalis corniculata;* W. *Paederia foetida;* X. *Psidium guajava;* Y. *Rubia cordifolia;* Z. *Schima wallichii*

Azadirachta indica *A. Juss.; Meliaceae (Mahanim-Assamese; Jikza-Zeliang; Neem-English)*

The juice of fresh leaves (8-10 drops) of *A. indica* is blended with milk and taken orally to forestall vomiting. Fresh leaf juice is applied in the treatment of aphthae. Dried leaves are powdered and taken (300-400 mg) with water to treat fever related to headaches and treat hypertension (Jamir et al. 1999). The ethanolic extract of *A. indica* has shown wound healing activity in male albino rats (Saini et al. 2016). Fresh leaves are consumed during stomach problems, cough, cold, pimples, fever, smallpox, and chickenpox (Debbarma et al. 2017). The *A. indica* powder, dried in the shade, and mixed with honey, is applied to treat leprosy. Fresh leaf juice is applied on cuts for blood clotting (Tripathi and Srivastava 2010). Leaf, bark, and fruits are used against skin infections and ulcers. It is also an antiseptic and insect repellant (Zhasa et al. 2015). The ethnic group of Nagaland traditionally uses fresh and dried leaves to treat skin diseases and dental disorders, the leaf paste is applied externally on piles by the Zeliang Tribe (pers. obs.).

Table 1. Details of ethnomedicinal plants used for wound healing and dermatological problems in North-Eastern Hill Region, India

Biological name and family name	Vernacular local/English name	Seasonal availability	Methods and parts used	Ailments cured
Ageratum Conyzoides (L.) L.; Asteraceae	Langtampuihei-Zeliang; Pru-Chakesang; Nhasa-Angami; Goatweed/Whiteweed-English	Jun.-Nov.	Mashed leaf is applied topically	Heals wounds, cuts, injuries and stops bleeding
Allium sativum L.; Alliaceae	Naharu-Assamese; Simria-Zeliang; Chiimeria-Angami; Garlic-English	Nov.-Mar.	Finely crushed root bulb, heated with mustard oil is used for massaging and can be eaten	Relief sore throat, common cold and wound
Aloe vera (L.) Burm. f.; Asphodelaceae	Alovira-Lotha	Year-round	Fresh stem is eaten as raw, topically applied on the skin	Treat burns, ulcers, surgical wounds, gastritis and apply as a moisturizer
Azadirachta indica A. Juss.; Meliaceae	Mahanim-Assamese; Jikza-Zeliang; Neem-English	Jan.-Aug.	Juice of fresh leaf blendedwith milk taken orally and leaf paste applied externally	Treat skin, piles, stomach problem and dental disorder
Calendula officinalis L.; Asteraceae	Narji-Assamese; Calendula-Nagamese; Dausure pa-Zeliang; Pot marigold-English	Nov.-May	Decoction of leaf and flower taken orally, leaf paste is applied topically	Treat internal problems, addresses myriad skin complaints
Carica papaya L.; Caricaceae	Mamatsi-Zeliang; Amethi-Lotha; Awathabi-Manipuri; Pawpaw-English	Oct.-Mar.	Crushed seeds made into a paste is applied to the skin, latex is applied topically	Treat skin ulcers, inflammation and fungal infections
Centella asiatica (L.) Urb.; Apiaceae	Hekaraineginei-Zeliang; Gapre-Chakesang; Peruk-Manipuri; Manimuni-Assamese; Gara-Angami; Asiatic pennywort/Indian pennywort-English	Year-round	Aerial part is taken raw, boiled or decoction	Treat skin disorder, skin infection and use as a blood purifier
Chromolaena odorota (L.) R.M.King & H.Rob.; Asteraceae	Chakchakpehei-Zeliang; Siam weed/ Christmas bush-English	Year-round	Leaf paste is applied on fresh cuts and wounds	Heals wounds, cuts, injuries and stops bleeding
Colocasia esculenta (L.) Schott; Araceae	Hebeu-Zeliang; Thomiilabi-Chakesang; Pan-Manipuri; Taro-English	Nov.-Feb.	Boiled corms are edible, the leaf is consumed as stews and soups and stem sap are used	Treat insect sting, cuts, burns, injuries, and internal hemorrhages
Crassocephalum crepidiodes (Benth.) S. Moore; Asteraceae	Heichiu-Zeliang; Ava Tabvo-Chakesang; Ragleaf/ Fireweed-English	Jan.-July	Crushed leaf is applied on wounds and cuts	Heals fresh cuts, wounds and stops bleeding
Curcuma longa L.; Zingiberaceae	Yai-ngang-Manipuri; Haladhi-Assamese; Nagamese-Haldi; Turmeric-English	Dec.-Mar.	Rhizome paste is used to apply on wounds and cuts. Decoction of rhizome is taken orally	Treat wounds, ulcers, cuts, cough, cold, scabies, dysentery and diarrhea
Emblica officinalis Gaertn; Phyllanthaceae	Heigru-Manipuri; Zaunamtsi-Zeliang; Aonla-Chakesang; Indian gooseberry-English	Aug.-Dec.	Crushed bark is used to treat wounds and cuts. Fruits and seeds can be eaten	Treat sores, wounds, cuts. Cures anemia, diarrhea, dysentery and jaundice
Euphorbia hirta L.; Euphorbiaceae	Zawhte-hlo-Mizo; Asthma plant-English	Year-round	Leaf paste is applied topically	Treat coryza, cough, wounds, asthma, injuries and abscesses
Euphorbia neriifolia L.; Euphorbiaceae	Tamrang-Zeliang; Indian spurge tree-English	Year-round	Juice and leaf paste is applied over the skin	Treat skin problems, piles and ulcers

Ficus religiosa L.; Moraceae	Nringbang-Zeliang; Sacred fig-English	Year-round	Leaf paste is applied topically. Bark is used to treat ulcers	Treat burn wounds, skin disease and ulcers
Hibiscus rosa-sinensis L.; Malvaceae	Nuhlupi-Mizo; Jubakusum-Manipuri; Chinese hibiscus-English	Year-round	Flower and leaf stem extracts are used. Mashed leaf is applied on hair	Relief periodic pains, spasms, cough, cold and soothes internal, external wounds and sores
Kalanchoe pinnata (Lam.) Pers.; Crassulaceae	Miruhei-Zeliang; Cathedral bells-English	Year-round	Mashed leaf and flower is applied topically	Heals wounds, burn injury, cuts. Treat sores, stop bleeding, infection and inflammation
Lantana camara L.; Verbenaceae	Nruiteuchi pa-Zeliang; Shrub verbena-English	Year-round	Leaf paste is applied topically. Decoction of mashed leaf and fruit are taken orally	Treat wounds, cuts, ulcers, swellings and relieve gastritis
Leucas aspera (Willd.) Linn.; Lamiaceae	Mi-nkierahei-Zeliang; Thumbai-English	Apr.-Oct.	Leaf plant extracts are taken orally	Treat skin disease, cough, fever, cold and relief inflammation
Mikania micrantha Kunth.; Asteraceae	Nagaria-Zeliang; Bitter vine/Climbing hemp vine-English	Year-round	Leaf juice and mashed leaf is applied topically on fresh cuts and wounds	Heals wounds, cuts and stops bleeding. Treat fever, stings, jaundice, diabetes, itches, cancer and dysentery
Mimosa pudica L.; Fabaceae	Hengamhei-Zeliang; Nilajiban-Assamese; Yikiratera-Lotha; Touch-me-not-English	Year-round	Leaf paste is applied topically. Extract of root and shoot is used to treat wounds	Arrest bleeding, treat cuts, wounds, diarrhea, bleeding piles and boils
Oxalis corniculata L.; Oxalidaceae	Thiizociitu-Chakesang; Nrampuinatangaine-Zeliang; Chingyensil-Manipuri; Tengeshi-tenga-Assamese; Creeping wood sorrel-English	Year-round	Decoction of the whole plant is used and leaf juice is applied topically	It cures skin eruption, burns wounds, sore throat. Treat influenza, snakebite and insect bite
Paederia foetida L.; Rubiaceae	Hebirim ria-Zeliang; Tevuro-Rengma; Stinkvine-English	Year-round	Decoction of mashed leaf and the whole plant is used to apply on swollen sprained joints and wounds	Treat asthma, bowel compliant, piles, diarrhea, promote skin wound restoration, diabetes, urinary retention and joints
Psidium guajava L.; Myrtaceae	Bamgotsi-Zeliang Pongtol-Manipuri; Guava-English	Aug.-Oct.	Leaf paste with few amount of water and oil is applied tothe wound. Raw leaves and fruit are consumed. Root, bark and immature fruit are used	Treat wounds, toothache, ulcers, dysentery, rheumatism and diarrhea
Rubia cordifolia L.; Rubiaceae	Majathi-Assamese; Indian madder-English	Aug.-Nov.	Used as antiseptic for wounds. Root is used for skin complications. Promote complexion	Treat wounds, skin itches, ulcers, eczema, swellings and cancer
Schima wallichii Choisy; Theaceae	Makriasal, nogabhe-Assamese; Khiang/Khainei/Pakhai-Mizo; Needlewood tree-English	Year-round	Juice of stem is used. Crushed fruit is boiled with water to apply in an insect bite. Bark is used as antiseptic	Stops bleeding, heals wounds and cuts. Treat gastritis, uterine issues and hysteria

Calendula officinalis *L.; Asteraceae (Narji-Assamese; Nagamese-Calendula, Dausure pa-Zeliang; Pot marigold-English)*

The *C. officinalis* has been traditionally and widely used in treating inflammations of internal organs, gastrointestinal ulcers and dysmenorrhea and as a diuretic and diaphoretic convulsions. It is also used for inflammations of the oral and pharyngeal mucosa, wounds and burns (Yoshikawa et al. 2001). The *C. officinalis* is a cleansing and detoxifying herb and the infusion treat chronic

infections (Blumenthal et al. 2001). The infusion deal with persistent infections. The dried flower heads were used for antipyretic, antitumor, and cicatrizing effects (Ukiya et al. 2006). The topical application of infusion of flowers is used as an antifungal and antiseptic in wounds, marks, freckles, sprain, and conjunctivitis (Rehecho et al. 2011). It treats various skin tumors, dermatological lesions, ulcers, swellings and nervous disorders (Arora et al. 2013). Mother tincture of *C. Officinalis* is utilized in homeopathy to treat mental tension and insomnia (Boericke 1998). The medicinal properties of *C. officinalis* were stated within the Ayurvedic and Unani medication systems, indicating that leaves and flowers are antipyretic, anti-inflammatory, antiepileptic, and antimicrobial (Kasiram et al. 2000). The *C. officinalis* offered anti-inflammatory and antibacterial activities in addition to angiogenic and fibroblastic properties (Maria et al. 2012). Elderly Zeliang Tribe people of Nagaland use *C. officinalis* as a vulnerary herb and also addresses myriad skin complaints like rashes, stings, wounds, burns, swellings, eczema, acne, insect bites, and bruises (pers. obs.).

Carica papaya *L.; Caricaceae (Mamatsi-Zeliang; Amethi-Lotha; Awathabi-Manipuri; Pawpaw-English)*

The *C. papaya* is traditionally accustomed to treating various skin disorders, as well as wounds. Tribals widely utilize it as a good and readily available treatment option for various wounds and burns (Nayak et al. 2012). The use of *C. papaya* in traditional medicine relies on papain, a proteolytic enzyme, which is the active principle that exerts an ulcer protective effect (Emeruwa 1982). A decoction from the seeds of *C. papaya* has been used to treat skin ulcers and inflammation. Studies suggested that *C. papaya* promotes significant wound healing in rats (Nayak et al. 2012). Seeds are crushed, made into a paste with honey, and applied to the face for pimples treatment (Ranibala and Das 2015). It is known to possess various pharmacologic properties like antioxidant, anti-inflammatory and wound healing (Anuar et al. 2008; Owoyele et al. 2008; Oboh et al. 2013;). Treatment of excision wound with papaya phosphate-buffered saline (PBS) extract (5 mg/ mL) with the addition of selenium (0.5 mg/20 mL) attenuates inflammation associated with oxidative damage and improves cutaneous wound healing (Nafiu and Rahman 2015). Leaves are used for removing corn and warts. Fruit helps in the digestion and flow of urine and constipation. Seeds are used as medicine for cancer treatment by the Sangtam, Angami, Zeliang, and Rengma Tribes of Nagaland (Zhasa et al. 2015). Elderly Zeliang and Rengma Tribes use the latex by applying topically to treat fungal infections and dried latex on the burn wound (pers. obs.). Papaya's anti-inflammatory and antioxidant properties are ascribed to primary and secondary bioactive components like papain, chymopapain, papaya lipase, and carotenoids. Lycopene, β-cryptoxanthin, and β-carotene reportedly have rich carotenoids in papaya fruit with proven antioxidant properties in the biological system (Rivera-Pastrana et al. 2010).

Centella asiatica *(L.) Urb.; Apiaceae (Hekaraineginei-Zeliang; Gapre-Chakesang; Peruk-Manipuri; Manimuni-Assamese; Gara-Angami; Asiatic pennywort/Indian pennywort-English)*

The *C. asiatica* is found throughout the year and grows well in damp, shady places, streams, and ponds. Some locals use the juice of the leaves (3-4 teaspoon) with an equal quantity of milk to treat diarrhea (Jamir et al. 1999). The entire plant is used in skin disorders, syphilis, rheumatism, leprosy, epilepsy, and nervous and immune system disorders (Zhasa et al. 2015). Triterpenes isolated from *C. asiatica* elevate collagen remodeling and glycosaminoglycan synthesis in a rat wound model. It has also been shown to facilitate scleroprotein synthesis and angiogenesis (Maquart et al. 1999; Liu et al. 2008). Local healers of the Zeliang Tribe used the whole plant for skin disorders and skin infections as a blood purifier by smashing the whole parts of the plant and drinking its decoction (pers. obs.). To treat sore throat/hypertension certain amount of the whole plant is boiled with about 2 liters of water and had as a decoction with a glassful 3 times a day. Repeat it till it is cured. One may have fresh leaves regularly as a culinary item to reduce hypertension or high blood pressure (Yuhlung and Bhattacharyya 2016). The *C. asiatica* can promote wound healing by inhibiting inflammation, promoting angiogenesis, inducing collagen synthesis, persuading vasodilation, and reducing wound oxidative stress. The extracts of *C. asiatica* have been shown to affect cell growth and proliferation in injured tissues (Somboonwong et al. 2012). The *C. asiatica* is suggested for treating several skin conditions like leprosy, lupus, varicose ulcers, eczema, psoriasis, diarrhea, fever, amenorrhea, diseases of the female genitourinary tract and also for relieving anxiety and improving cognition (Gohil et al. 2010).

Chromolaena odorata *(L.) R.M.King & H.Rob.; Asteraceae (Chakchakpehei-Zeliang; Siam weed/Christmas bush-English)*

The *C. odorata* leaves are crushed and applied to wounds and cuts. Crushed leaves are also applied around the anus against pinworms. It is also effective for clotting blood from cuts and wounds (Bhardwaj and Gakhar 2005). The performance of healing wounds might be due to the antioxidant property of the plant, which enhances conserving the fibroblast and keratinocyte proliferation in wounds (Vaisakh and Pandey 2012). The *C. odorata* is popularly used for traditional wound healing, and the leave aqueous extract has been used to treat soft-tissue burns or skin infections (Anushik and Wannee 2017). The *C. odorata* promotes wound healing by stopping bleeding, which can be the first step in healing (Anushika and Wannee 2017). Ethnic groups of Zeliang, Angami, and Chakesang Tribes use the leaves paste to heal fresh cuts and wounds to stop bleeding (pers. obs.). The fresh leaves of *C. odorata* by decoction have been used by traditional practitioners for treating human burns, soft tissue wounds, ulcerated wounds, burn wounds, postnatal wounds and also for treating leech bites, indigestion, and skin infection (Panyaphu et al. 2011). The decoctions of the stems of *C.*

odorata were reported to be effective in treating skin diseases caused by *Propionibacterium acnes* (Pandurangan et al. 2015).

Colocasia esculenta *(L.) Schott; Araceae (Hebeu-Zeliang; Thomiilabi-Chakesang; Pan-Manipuri; Taro-English)*

The *C. esculenta* is an essential food for millions of people. The leaves are consumed in sauces, purees, stews, and soups. It is also used in wound healing treatment (Gonçalves et al. 2013). The health benefits of taro might be due to its antioxidants and anticancer activities. The *C. esculenta* corms are edible and used by the Sangtam, Angami, and Zeliang Tribes for treating insect stings, cuts, burns, injuries, and internal hemorrhages (Zhasa et al. 2015). Stem sap to a bee sting and insect bites by Chakesang Tribe (Nelia and Limasenla 2020). To heal the spike on heel, *C. esculenta* tuber is cut and pasted or bandaged around the heel for three to four days (Yuhlung and Bhattacharyya 2016). The *C. esculenta* is called 'Kuchu' in Nagaland (pers. obs.). The *C. esculenta* has wound healing potential and can be ascribed to protecting the wound site against oxidative/nitrosative damage and prevention of hyaluronic acid degradation (Gonçalves et al. 2013). The *C. esculenta* leaf extract has antibacterial, antifungal, anti-inflammatory, and antimicrobial effects. Some phytochemicals like saponins and tannins excite the secretion of growth factors that can affect fibroblast proliferation (Li et al. 2016). The *C. esculenta* is also traditionally used as medicine for scarring purposes, from various studies. Many studies also revealed that *C. esculenta* contains bioactive components with some important components like anticancer, antihyperlipidemic, anti melanogenic, wound healing, anti-inflammatory, probiotics, antihypertensive, antioxidants, antimicrobials (Agyare and Boakye 2015; Pereira et al. 2015).

Crassocephalum crepidioides *(Benth.) S. Moore.; Asteraceae (Heichiu-Zeliang; Ava Tabvo-Chakesang; Ragleaf/Fireweed-English)*

The *C. crepidioides* leaf juice is applied regionally to wounds for fast healing (Ranibala and Das 2015). Although there are not several scientific shreds of evidence concerning its wound healing activity, some tribals use it to treat minor wounds. The herb's wound healing effects would possibly support its capacities of antioxidant, anti-inflammation, fibroblast proliferation, and angiogenesis (Can and Thao 2020). Leaf paste to cuts and wounds as hemostatic by the Chakesang Tribe of Nagaland (Nelia and Limasenla 2020). The leaves of *C. crepidioides* are traditionally accustomed to treat indigestion, stomachache, and wound (Lemmens and Bunyapraphatsara 2003; Grubben and Denton 2004; Loi 2004; Adetutu et al. 2011; Owokotomo et al. 2012). The *C. crepidioides* leaf has wound healing activity due to its antioxidant, anti-inflammation, fibroblast proliferation, wound contraction, and angiogenesis effects (Can and Thao 2020). Many bioactive compounds have been found in *C. crepidioides* leaves, including some phenoplast and flavonoid compounds; the essential oil from *C. crepidioides* leaves contain β-cubebene, α-farnesene, and α-caryophyllene (Can and Thao 2020). According to the local tribes and ethnic groups in the NE region, the Zeliang, Angami, Rengma, Yimkhiung and Sumi Tribes use crushed leaves of *C. crepidioides* to heal fresh wounds and cuts (pers. obs.).

Curcuma longa *L.; Zingiberaceae (Yai-ngang angouba-Manipuri; Haladhi-Assamese, Nagamese-Haldi; Turmeric-English)*

The *C. longa* is an antique spice and a beneficial herb of Ayurvedic medicine. Curcumin, a potent antioxidant, is the essential bioactive component of the herb turmeric and possesses anti-inflammatory, anti-platelet, cholesterol-lowering, antibacterial, and antifungal effects. In addition, Curcumin enhances fibroblast proliferation, granulation tissue formation, and collagen deposition in cutaneous wound healing (Shedoeva et al. 2019). Purohit et al. (2013) investigated that ethanolic extract of *C. longa* rhizomes has a better and quicker wound recuperation effect than ointment in the excision wound model.

The tuber is mashed, warmed, and applied on wounds, skin problems, and cuts. Turmeric tuber also can be used as an expectorant. It is antiseptic and may be utilized in ulcers and wounds. The fungicidal activity of turmeric has additionally been proved. Pure turmeric paste product helps treat scabies (Velayudhan et al. 2012). It is also consumed to treat cough and cold. The rhizome is also taken against food poisoning, diarrhea, dysentery, and typhoid (Bhardwaj and Gakhar 2005). To treat pigmentation/ black/ dark spots/ pimples, the rhizome (turmeric) is mixed with little mustard oil, and apply the paste regularly on the area before bedtime (Yuhlung and Bhattacharyya 2016). According to the information gathered from the local tribes and ethnic groups of the NE region, *C. longa* paste (rhizome) is used for treating wounds and cuts by applying topically and treating cold by decoction (pers. obs.).

Emblica officinalis *Gaertn; Phyllanthaceae (Heigru-Manipuri; Zaunamtsi-Zeliang; Aonla-Chakesang; Indian gooseberry-English)*

The crushed bark has been traditionally used to treat wounds, and cuts, whereas the fruits have a laxative impact (Bhardwaj and Gakhar 2005). Fruit extract of *E. officinalis* has been consumed to treat cough, diabetes, cold, and acidity (Bharali et al. 2017). Fruits and seeds are accustomed to curing anemia, dysentery, diarrhea, hemorrhage, eye inflammation, jaundice, leucorrhoea and menorrhagia, and injury wounds. The inner tender barks are scraped and applied to the wound to tighten the muscles and cure the injury, used by the Lotha and Ao Tribes of Nagaland (Zhasa et al. 2015). The *E. officinalis* is used to defend the skin from the devastating effects of free radicals, non-radicals, and transition metal-induced oxidative stress and has been reported for antimicrobial activities. The juice of the leaves could be an excellent application to sores. It possesses antioxidant, anticancer, antitumor, antigenotoxic, and anticarcinogenic effects and different medical specialty or biological activities. It is considered a secure herbal medicine without adverse effects (Jain et al. 2016). From the survey, it was reported

from an ethnic group that fruits of *E. officinalis* are eaten to treat high blood pressure, act as a blood purifier, and help in digestion (pers. obs.). The bark and leaf paste of *E. officinalis* is applied to the allergic-affected area daily until it cures (Policepatel and Manikrao 2013).

Euphorbia hirta *L.; Euphorbiaceae (Zawhte-hlo-Mizo; Asthma weed-English)*

The *E. hirta* is a small, upright, or ascending annual herb up to 50 cm in height and has hairy stems. The *E. hirta* leaves treat coryza, cough, asthma, bronchial infections, intestinal discomfort, helminth infestations, wounds, stone kidneys, and abscesses (Kumar et al. 2010). Latex is applied against skin parasites twice a day till it is cured. Latex is also applied to destroy warts (Tripathi and Srivastava 2010). The *E. hirta* plant is famous for its medicinal importance in the tribal population and it is a common practice to use the whole plant for wound healing (Tuhin et al. 2017). Aqueous plant extract shows analgesic, antipyretic, anxiolytic, sedative, and medicinal drug activities and additional restrictive action on thrombocyte aggregation. It has been found that the ethanolic extract of the whole herb of *E. hirta* holds important wound healing activity (Nagori and Solanki 2011). Various pharmacological properties, including antiseptic, anti-inflammatory, antidiabetic, antispasmodic, antibacterial, and antiviral, have antifungal, antispasmodic, nootropic, antifertility and aphrodisiac properties of this plant has been reported (Tuhin et al. 2017). The elderly Zeliang Tribe uses the leaf paste of *E. hirta* to treat wounds (pers. obs.). The *E. hirta* has been used as a remedy for various skin and dermatological disorders, especially cuts, wounds and burns (Kumar et al. 2007). The ethanolic extract of *E. hirta* significantly reduces free radicals stress and helps prevent inflammation and oxidative damage, eventually promoting wound healing (Tuhin et al. 2017).

Euphorbia neriifolia *L.; Euphorbiaceae (Tamrang-Zeliang; Indian spurge tree-English)*

The *E. neriifolia* grows luxuriously and extensively across Nagaland's dry, rocky, and hilly regions. Bigoniya and Rana (2007) evaluated the wound healing activity of *E. neriifolia* leaf on excision and dead space wound model. The *E. neriifolia* augmented wound contraction and epithelisation with the aid of an enriched amount of protein and hydroxyproline content. Gaur et al. (2009) demonstrated the anti-inflammatory and analgesic impact of the hydroalcoholic leaf extract of this plant. The *E. neriifolia* has extensive applications in traditional medicines, including the treatment of abdominal troubles, bronchitis, tumors, leucoderma, piles, inflammation, spleen enlargement, anemia, cutaneous diseases, ulcers, fever, and chronic respiration troubles. It is an analgesic, hepatoprotective, immunostimulant, anti-inflammatory, wound healing, and radioprotective agent (Thorat and Bolli 2017). Fresh leaf latex is rubbed on the skin to cure wounds and pimples (Tripathi and Srivastava 2010). Traditionally the leaf of *E. neriifolia* is heated and tied over the affected area to relieve ache and inflammation. The fresh juice from the leaf is poured into the ear to deal with an earache. In addition, the juice is used to treat skin warts and arthritis. The milk latex of *E. neriifolia* is applied over warts as a part of the treatment, and the leaf paste is applied over the skin to deal with skin diseases (Thorat and Bolli 2017). According to local healers of Nagaland, they use the milk latex of *E. neriifolia* to apply to different skin problems by Zeliang, Angami, and Rengma Tribes (pers. obs.).

Ficus religiosa *L.; Moraceae (Nringbang-Zeliang; Sacred fig-English)*

The *F. religiosa* is a substantial perennial tree, glabrous when young, found throughout the plains of Nagaland. The plants are mainly used in traditional Indian drugs for various ailments. Traditionally, the bark is utilized as an antibacterial, antiprotozoal, antiviral, astringent, and antidiarrhoeal to treat gonorrhea ulcers (Chandrasekhar et al. 2010). Roots of *F. religiosa* are used in treatment for gout, skin disease, lower back pain, inflammatory disease of the mouth, ulcer, purgative, and leaf juice is used to treat asthma, cough, sexual disorder, diarrhea, hematuria, toothache, eye trouble, wounds, scabies, diarrhea and skin diseases (Chandrasekhar et al. 2010; Makhijia et al. 2010). The *F. religiosa* has medicinal applications for gynecological problems, dysentery, wound healing, inflammatory, analgesic, and anti-lipid-peroxidation activity (Suganthy et al. 2020). The leaves are used for skin diseases and wounds. The leaves are reported to have antivenom activity and are also shown to regulate the menstrual cycle. It is effective against cancer, inflammation, or infectious diseases (Chandrasekhar et al. 2010). The bark of *F. religiosa* has wound healing activity, analgesic, anti-lipid-peroxidation activity, purgative properties (tender shoots), and anti-inflammatory (Roy et al. 2009). Leaves of *F. religiosa* are usually applied to wounds, skin diseases, and scabies (Yadav 2015). The hydroalcoholic extract of *F. religiosa* leaves showed a dose-dependent wound-healing effect on excision, incision, and burn wounds (Chandrasekar et al. 2010).

Hibiscus rosa-sinensis *L.; Malvaceae (Nuhlupi-Mizo; Jubakusum-Manipuri; Chinese hibiscus-English)*

The *H. rosa-sinensis* is an evergreen shrub native to tropical South-Eastern Asia. The flowers of *H. rosa-sinensis* are edible. Traditional texts describe preparations of the leaves and flowers to promote hair growth and prevent greying (Adhirajan et al. 2003). Extracts from *H. rosa-sinensis* have also been found to have antibacterial and wound healing properties (Nayak et al. 2007; Khan et al. 2014). They attenuate inflammation, enhance fibroblast proliferation and collagen deposition, as well as upregulate VEGF and TGFβ1 expression in rat excisional wounds (Shen et al. 2017). Women use leaf juice to treat infertility. The root is used for mouthwash. Bud, root paste, and rice water are prescribed for irregular menstruation (Debbarma et al. 2017). *Traditionally, hibiscus flowers* have been reported to possess antitumor properties as analgesic, antipyretic, anti-asthmatic, and anti-inflammatory agents. Studies have also proved the presence of antioxidant, antifungal, and antimicrobial properties in flowers of *H. rosa-sinensis* (Vastrad and Byadgi 2018). It has various

important medicinal uses for treating wounds, inflammation, fever, coughs, and diabetes (Missoum 2018). Lotha, Sangtam, and Ao Tribes of Nagaland use flowers and stem extracts to relieve periodic pains, spasms, cures sexually transmitted diseases, coughs, and colds. It soothes internal and external wounds, as well as sores (Zhasa et al. 2015). Methanol extracts prepared from the leaves of *H. rosa-sinensis* were shown to have antimicrobial activities (Hemarana et al. 2014).

Kalanchoe pinnata *(Lam.) Pers.; Crassulaceae (Miruhei-Zeliang; Lotsitse-Chakesang; Cathedral bells-English)*

The *K. pinnata* is a succulent plant. The *K. pinnata* is commonly known as a 'Master Herb' or a 'cure for all by a large community of herbal practitioners in the Caribbean region. In traditional medicine, *Kalanchoe* species have been used for various ailments such as infections, rheumatism, and inflammation. It was found that ethanolic extract of *K. pinnata* facilitates significant wound healing. Its wound healing promotion activity could be due to the potential antioxidant activity of the presence of enriched polyphenolic derivatives (Nayak et al. 2010). Leaves are antibacterial; they soothe irritation, inflammatory skin burns, amoebic dysentery, diabetes, and eyes (Zhasa et al. 2015). The leaf extract is used in bloody dysentery (Debbarma et al. 2017). Zeliang, Angami, Rengma, and Konyak Tribes of Nagaland use mashed leaves and flowers to treat sores, and it helps to stop bleeding from wounds, cuts, and burns injuries (pers. obs.). The decoction of the leaf is taken for kidney problems by the Chakesang Tribe (Nelia and Limasenla 2020).

Lantana camara *L.; Verbenaceae (Nruiteuchi pa-Zeliang; Shrub verbena-English)*

The *L. camara* is a flowering ornamental plant abundantly available in Nagaland. The *L. camara* is used in herbal medicine to treat skin itches, as an antiseptic for wounds, and externally for leprosy and scabies (Nayak et al. 2009). Freshly crushed fruits and leaves are applied to wounds. The decoction of mashed leaves and fruits are given to drink to relieve gastritis and is associated with the treatment of colic problem and antispasmodic properties (Zhasa et al. 2015). Fresh leaves of *L. camara* have been traditionally used on measles in some tribes (De Wet et al. 2013). Treatment of the wounds with extract significantly enhanced the rate of wound contraction (98%), collagen synthesis, and decreased mean wound healing time. These studies demonstrate that *L. camara* is effective in healing excision wounds in experimental animals and could be evaluated as a therapeutic agent in tissue repair processes associated with skin injuries (Nayak et al. 2009). The *L. camara* is used traditionally to treat various diseases like cancers, chickenpox, asthma, ulcers, swellings, eczema, tumors, measles, high blood pressure, bilious fevers, catarrhal infections, tetanus, rheumatism, and malaria (Farah et al. 2018). Some parts of the plant are used in treating itches, cuts, ulcers, swellings, bilious fever, catarrh, eczema, dysentery, and chest complaints in children (Deena and Thoppil 2000). Externally for leprosy and scabies (Ghisalberti 2000). Plant extracts are used in folk medicine for the treatment of cancers, chicken pox, measles, asthma, ulcers, swellings, eczema, tumors, high blood pressure, bilious fevers, catarrhal infections, tetanus, rheumatism, malaria of abdominal viscera (Day et al. 2003; Saxena et al. 2012). Extracts from the leaves exhibit anti-proliferative, antimicrobial, fungicidal, insecticidal, and nematicidal activity (Saxena et al. 1992; Begun et al. 1995; Sharma et al. 1999; Day et al. 2003). The interactions with the ethnic group of the Zeliang Tribe informed that the leaves of *L. camara* are used as an expectorant. The pounded leaves are applied as a paste to heal cuts, ulcers, and local swellings. Another method is using crushed leaves with coconut oil to treat dermatological problems, and whole plant parts are usually used for herbal preparations (pers. obs.). The leaves of the plant are boiled and used for tea, and it is a remedy against cough by decoction and pounded leaves are also used as a lotion for wounds and are applied to cuts, ulcers, and swellings (Verma and Verma 2006).

Leucas aspera *(Willd.) Linn; Lamiaceae (Mi-nkierahei-Zeliang; Thumbai-English)*

The *L. aspera* is an annual, branched, and herbaceous medicinal weed. The plant parts are used traditionally as an antipyretic and insecticidal agent, and the flowers are valued as a stimulant, expectorant, and diaphoretic. The leaves of the plants are also helpful in treating chronic rheumatism, psoriasis, and other chronic skin diseases (Choudhury et al. 2020). Leaf paste is directly consumed, or the leaves are cooked and taken as a vegetable for pain relief, gastric problems, and joint pain with swelling (Debbarma et al. 2017). The plant extracts help to reduce fever, cough, and cold. It is also used to give fragrance to food. The juice of the flowers was used in folklore medicine for intestinal worm infections in children. The leaves are frequently used to heal psoriasis, skin disorder, headaches and to relieve painful inflammations. Traditionally, young vegetative shoots and flowers of *L. aspera* and in combination with an equal amount of fruits of some medicinal plants, are taken orally to cure dysmenorrheal. All the parts of *L. aspera* showed various pharmacological properties (Srinivasan et al. 2011). Ethnic groups of the Zeliang Tribe use the crushed flower to treat colds, injuries and sinusitis. Decoction of flower and leaf is also used to treat cold (pers. obs.).

Mikania micrantha *Kunth; Asteraceae (Nagaria-Zeliang; Bitter vine/Climbing hemp vine-English)*

The *M. micrantha* leaves juice has been traditionally used to fasten the blood clot after cuts and wounds. Leaves are boiled in water, and the water is given to the patient suffering from dysentery (Bhardwaj and Gakhar 2005). Tribals use unique components of *M. micrantha* to treat fever, jaundice, dysentery, rheumatism, diabetes, colds, respiratory diseases, and scorpion stings (Rahim et al. 2012; Rufatto et al. 2012). The *M. micrantha* leaves have been reported as an excellent hemostatic agent (Basumatary et al. 2004; Bhardwaj and Gakhar 2005; Ayyanar and Ignacimuthu 2009; Rai and Lalramnghinglova 2010; Khisha et al. 2012;). The *M. micrantha* is

traditionally used as a medicinal plant for various health conditions worldwide (Sathi et al. 2015). In ethnoveterinary medicine, the plant deals with diarrhea of veterinary animals and repels the body lice of poultry birds (Rout et al. 2010; Saha et al. 2014). The *M. micrantha* indicates its wide range of medicinal properties, including antitumor, anti-inflammatory, and antibacterial activity (Chung et al. 1998; Yao et al. 2004; Banerjee et al. 2014). The local tribes of Nagaland use mashed leaves to apply to fresh cuts, injuries, and wounds to stop bleeding (pers. obs.).

Mimosa pudica *L.; Fabaceae (Hengamhei-Zeliang; Nuovipru-Chakesang; Nilajiban-Assamese; Yikiratera-Lotha; Touch-me-not-English)*

The *M. pudica* is a short prickly plant with branches growing close to the ground. In traditional healthcare systems, *M. pudica* plant leaves, flowers, stems, roots, and fruits treat various ailments. The content material of *M. pudica* is shown to arrest bleeding and fasten the healing process of wounds. Local healers usually recommend this plant for treating cuts, wounds, diarrhea, amoebic dysentery, and bleeding piles. It is likewise utilized in natural preparations for gynecological disorders. It is effective in relieving the symptoms of rheumatoid arthritis (Joseph et al. 2013). Roots and leaves decoction is used to treat leucorrhoea and urinary problems; leaf paste is applied to skin infections (Nelia and Limasenla 2020). All three parts possess medicinal properties and treat biliousness, leprosy, dysentery, vaginal, uterine complaints, inflammations, burning sensation, fatigue, asthma, leucoderma, and blood diseases (Chauhan and Johnson 2009). The *methanolic extract's M. pudica* shoot and root showed very good wound healing activity (Kannan et al. 2009). According to the elderly local tribal people of the Zeliang Tribe, the mashed leaves are used to treat boils and piles (pers. obs.).

Oxalis corniculata *L.; Oxalidaceae (Thiizociitu-Chakesang; Nrampuina-tangaine-Zeliang; Chingyensil-Manipuri; Tengeshi-tenga-Assamese; Creeping wood sorrel-English)*

The *O. corniculata* were substantially utilized in traditional medicine to cure innumerable ailments like skin infections, piles, healing wounds, treating diarrhea, and cure diseases like cancer, anemia, convulsion, and dyspepsia. Modern medicine has recounted many properties like antioxidant properties, antimicrobial, anti-inflammatory, and wound recuperation, in addition to hepatoprotective properties of the extracts of *O. corniculata* (Rashmi and Sahu 2020). The decoction of the plant is taken to treat diarrhea. Leaf juice is used to remove warts and treat wounds and eczema; leaves are crushed and used to wash latex or sap stains from hands (Nelia and Limasenla 2020). To treat arthritis/ rheumatism (joint pain), the leaf part is boiled and served as a decoction, a glass full 2/3 a day till it cures. It may also be served as a culinary item (Yuhlung and Bhattacharyya 2016). The leaves of this plant are used for healing stomach problems and even as antivenom. The whole plant's paste is applied at the site of the snake bite. To get alleviation from inflammation, the poultice of *O. corniculata* leaves may be applied over the inflamed spot. The infusion made from the leaves can be used to get rid of cornea opacities. Additionally, it may be used to cure itchy eyes by pouring a few drops into the eye. The whole plant decoction is used to get relief from throat infections by gargling. The juice of these plant leaves is used to deal with insect bites, skin eruptions, and burns (Rashmi and Sahu 2020). Zeliang and Ao Tribes of Nagaland use the leaf of *O. corniculata* to deal with different illnesses like influenza, urinary tract infection, enteritis, diarrhea, traumatic injuries, sprains, and poisonous snake bites (Bharali et al. 2017). The whole plant of *O. corniculata* is used as a remedy for scurvy, cataract, boil, wound, eczema, dysentery, diarrhea and used as an appetizer (Zhasa et al. 2015).

Paederia foetida *L.; Rubiaceae (Hebirim ria-Zeliang; Tevuro-Rengma; Stinkvine-English)*

The *P. foetida* is a climbing, herbaceous, hairy, and clean thin vine. The indigenous or traditional practitioners use *P. foetida* for the treatment of numerous diseases. In Ayurveda, it is considered an effective plant extract for antiarthritic, antispasmodic, diaphoretic, expectorant, and stomachic. Similarly, it is also utilized in asthma, bowel complaints, diarrhea, diabetes, seminal weakness, etc. It is also reported to be used in gout, vesical calculi, diarrhea, dysentery, piles, irritation of the liver, and emetic. It was used for rheumatism in folkloric, and bark decoction is used as an emetic (Chauhan et al. 2010). The leaves are mashed, boiled, and applied to the abdomen for urinary retention. Decoction of leaves is extensively utilized for urinary retention and urinary bladder stones. Decoction-soaked clothes are applied to the forehead for fevers, sprained joints and consumed simultaneously (Chauhan et al. 2010). The root extract treats pile problems, spleen inflammation, and aches in the chest and liver (Zhasa et al. 2015). Some findings recommend that *P. foetida* Flower Absolute (PFFA) promotes skin wound restoration by stimulating migratory and proliferative activities, collagen synthesis, and skin barrier restoration of epidermal keratinocytes. PFFA can be beneficial for developing agents that enhance skin wound and barrier-repair functions (Kim et al. 2020). Leaf extract is applied to ease ear pain; leaf juice is taken for diarrhea and dysentery (Nelia and Limasenla 2020). According to the local ethnic group, tribal people use the whole plant in soaked clothes by decoction to apply on the swollen sprained joints to relieve pain (pers. obs.). Decoction of leaves is used for antirheumatic baths. Pounded leaves are implemented on the abdomen for flatulence. Decoction of roots has been used for expelling the gases (Chauhan et al. 2010). A study showed that *P. foetida* has high antioxidant activity and suggested that it could be a significant source of natural antioxidant compounds (Osman et al. 2009).

Psidium guajava *L.; Myrtaceae (Bamgotsi-Zeliang; Pongtol-Manipuri; Guava-English):*

The *P. guajava* leaves have been traditionally used for healing various wounds. Tribals use *Psidium*

guajava leaves made into a paste by grinding with little water or oil, and the same was applied to the wound surface (Lam et al. 2016). Tender shoots are taken directly by chewing or paste to treat diarrhea, dysentery, piles, and vomiting (Debbarma et al. 2017). Tannins and flavonoids exhibited faster healing of experimental wounds when applied with the methanolic extract of guava leaves. Many researchers have proved that ointment made from guava leaves can cure wounds far faster than the available medicine (Lam et al. 2016). Roots, bark, leaves, and immature fruits are used as astringent to treat wounds, ulcers, rheumatism, toothache, dysentery, diarrhea, vermifuge, and leucorrhea by the Sangtam and Zeliang Tribes of Nagaland (Zhasa et al. 2015). Raw fresh leaves are chewed to control dysentery. Young shoots and leaves treat diarrhea and dysentery (Singh et al. 2019).

Rubia cordifolia *L.; Rubiaceae (Majathi-Assamese; Indian madder-English)*

The *R. cordifolia* is used by folklore traditions in India to treat cuts, wounds, and burns. The *R. cordifolia* is popular all over the world for its medicinal uses in skin diseases like eczema, dermatitis, skin ulcers, etc. It is traditionally used for various skin diseases (Karodi et al. 2009). It has a variety of uses such as blood purifier, immunomodulator (Joharapurkar et al. 2003), anti-inflammatory (Antarkar et al. 1983) and antioxidant (Tripathi and Sharma 1998). The chiefly valuable plant part is its rootstocks, which contain phytochemicals like anthraquinone, terpenes, glycosides, etc., and are recognized as the active curative agents to wide and diverse forms of ailments (Devi and Seril 2014). Traditionally, it is used in many polyherbal formulations for numerous illnesses and cosmetic preparations due to its anti-inflammatory, antiseptic and galactopurifier activity (Bechtold and Mussak 2009). Roots, leaves, and stems have antibacterial, antifungal, antiseptic, and antidysenteric to prepare phyto medicine used by the Lotha and Ao Tribes of Nagaland (Zhasa et al. 2015). The roots of *R. cordifolia* are used for laxative, analgesic, rheumatism, dropsy, paralysis and intestinal ulcers and its dried stem is used in blood, skin and urinogenital disorders, dysentery, piles, ulcers, inflammations, erysipelas, skin diseases and rheumatism (Khare 2004).

Schima wallichii *Choisy; Theaceae (Makriasal, nogabhe-Assamese; Khiang/Khainei/Pakhai-Mizo; Needlewood tree-English)*

The juice stem of *S. wallichii* is used to stop bleeding from cuts and is additionally used as an antiseptic. The bark is a good antihelminthic and rubefacient. The crushed fruit is boiled with water and applied to treat the bite of spiders, scorpions, etc. (Bhardwaj and Gakhar 2005). The tree is a rich source of tannins and oil. The astringent corollas are used to deal with uterine issues and hysteria. The bark is used as an antiseptic for wounds and sap from the stem is used to treat ear infections (Tribal community of NE region). The Sema Tribe of Nagas uses *S. wallichii* mostly as antiseptic in wounds (Bhattacharjee et al. 2019). Lalrinzuali et al. (2015) have reported its uses to treat snake/insect bites and antiseptic properties of fruits and the bark powder is used to treat gastric problems.

Discussions

Wound healing is an intricate process continued with numerous cellular events. Hemostasis, inflammation, proliferation, and dermal remodeling are four distinct overlapping phases of wound healing. An important component of tissue healing and wound contraction is the rearrangement of ground collagen fibers, which can ultimately influence the quality of scars. The extracellular matrix functions as a reservoir for growth factors and signaling molecules and acts as a framework upon which endothelial cells can migrate during angiogenesis (DiPietro 1995; Li et al. 2003). The traditional healing system is unique, and these strategies are adopted by the rural tribals for sustenance and remedies for different ailments by using wild flora. Humans and plants share an age-old relationship. Dependence on plants is still seen and it is estimated that 25% of prescription drugs contain active components derived from higher plants (Tiwari and Joshi 1990; Das and Choudhury 2012). It has been estimated by WHO that at least 80% of the world population, mainly in developing countries, is still dependent on herbal medicines for their primary health care needs. The use of traditional medicine is based on its accessibility, affordability and its firm embedment within the people's faith systems (Kamboj 2000; Galabuzi et al. 2010). The tribal people living in rural areas cannot afford and do not have access to proper health care systems. Therefore, they largely depend on the indigenous knowledge of traditional medicines. Still today, the bioresources are so intrinsically interwoven with the lifestyle of tribals that medicinal plants are an inseparable part of the poor tribal communities (Zhasa et al. 2015). Depending upon the degree and types of illness, magico-religious ceremonies are organized along with ethnobotanical plants by the village priest or local medicine-man to heal and cure the dreaded diseases, including dermatological problems. Some information about the indigenous medicinal plants was gathered from the ethnic group within the local community through personal interaction. However, their recipes, compositions, drug preparation techniques, mode of use, and adding ingredients were different. Our present study particularly focused on wound healing and dermatological problems. We have selected plants that are abundantly available in our local region and plant species mostly used by ethnic groups to treat wounds, cuts, bruises, and skin diseases, including in our review article. The fascinating thing about medicinal plant species is that they have high phytochemical diversity, many of which possess interesting biological activities and medicinal properties, which is why they can cure and heal minor or different dreaded diseases.

Ethnic groups possess rich knowledge concerning diagnosing and treating significant to minor diseases and are typically specialists in the art of ancient medicine in their community. Indigenous traditional knowledge (ITK) is obtained through time for the local traditional healers. Most of those well-known possess substantive knowledge and principally practice for ages without scientific

knowledge and proper guidance but keeping in mind that ITK is passed on from one generation to another over time.

The information which was gathered from local ethnic groups was that it does not actually characterize particularly how precisely this interaction was initiated and convinced by the local traditional healer, but they interacted through personal communication by sharing their knowledge. Modern drugs are critical in treating and curing diseases; however, several tribal communities lack a physiological condition care system as their economies are engaged in subsistence agriculture. Moreover, they cannot afford the cost of modern medicines as ethnomedicinal practices are favored because they are more accessible, have low costs, are easy to prepare, and are eco-friendly. Knowledge of folk uses of medicinal plants opens up new avenues for the effective use of medicinal herbs in the future. Future work in this direction may help discover new drugs to treat wounds and dermatological problems though very little information about the scientific validation of the plant is still ongoing and limited. It should be our main aim to help propagate Indigenous Traditional Knowledge (ITK) developed by tribals to validate and treat various ailments related to humans and animals, the knowledge of these practices must reach the end-user for their benefit. Enormous clinical trials or clinical research are required to give positive evidence supporting the use of traditional medicine by creating awareness the benefit of using medicinal plants, and genuine good documentation should be encouraged.

In conclusion, the use of medicinal plants and their products to cure different ailments has been reported and documented, but still, confirmation and periodic clinical tests on the efficacy of these medicinal plants are yet to be scientifically validated or verified. However, combining traditional and modern knowledge can also produce better drugs/results for wound healing, dermatological complications and other diseases with fewer side effects. The local healers do not like to disclose, nor are they willing to share their traditional knowledge with others. It is because revealing their Indigenous Traditional Knowledge might affect their source of income and purposeless harvesting for their economic use may deplete these valuable plants. We should try to convince and explain the importance of useful plant species, which need to be conserved, and should be judicially utilized. Research reveals that there are numerous ways to improve the health care of the poor tribal based on the existing wealth gifted by Mother Nature and in fact, many medicinal plants are still yet to be explored. Valuable medicinal plants can undergo genuine analysis of herbal formulations and phytoconstituents of plants as it can open a new scope for researchers. The knowledge of various indigenous medicinal plants from village elderly and local healers can be of immense significance to herbal medicine researchers and the local population. Therefore, it is necessary to publicize these medicinal plants' recognition, utility and value. The treasure of Indigenous Traditional Knowledge may further be explored and validated clinically for effective use and acknowledging it is very important in motivating the local people, especially the rising generation, to carry this noble tradition for generations to come.

ACKNOWLEDGEMENTS

The authors are highly thankful to Vice-Chancellor, Central Agricultural University, India, for providing the necessary facilities to compile this review. We also thank the local ethnic groups for helping us throughout during personal interaction and acknowledge their cooperation.

REFERENCES

Adetutu A, Morgan WA, Corcoran O. 2011. Ethnopharmacological survey and in vitro evaluation of wound-healing plants used in South-Western Nigeria. J Ethnopharmacol 137 (1): 50-56. DOI: 10.1016/j.jep.2011.03.073.

Adhirajan N, Kumar RT, Shanmugasundaram N, Babu M. 2003. In vivo and in vitro evaluation of hair growth potential of *Hibiscus rosa-sinensis* Linn. J Ethnopharmacol 88 (2-3): 235-239. DOI: 10.1016/s0378-8741(03)00231-9.

Agyare C, Boakye YD. 2015. Antimicrobial and anti-inflammatory properties of *Anchomanes difformis* (Bl.) Engl. and *Colocasia esculenta* (L.) Schott. Biochem Pharmacol 5: 1. DOI: 10.4172/2167-0501.1000201.

Akhtar MS, Degaga B, Azam T. 2014. Antimicrobial activity of essential oils extracted from medicinal plants against the pathogenic microorganisms: A review. Issues Biol Sci Pharm Res 2: 1-7.

Antarkar SS, Chinwalla T, Bhatt N. 1983. Anti-inflammatory activity of *Rubia cordifolia* Linn. In rats. Indian J Pharmacol 15 (3): 185-188.

Anuar NS, Zahari SS, Taib IA, Rahman MT. 2008. Effect of green and ripe *Carica papaya* epicarp extracts on wound healing and during pregnancy. Food Chem Toxicol 46: 2384-2389. DOI: 10.1016/j.fct.2008.03.025.

Anushika S, Wannee J. 2017. Wound healing property review of siam weed, *Chromolaena odorata*. Pharmacogn Rev 11 (21): 38. DOI: 10.4103/phrev.phrev_ 53_16.

Arora D, Rani A, Sharma A. 2013. A review on phytochemistry and ethnopharmacological aspects of genus *Calendula*. Pharmacogn Rev 7 (14): 179-187. DOI: 10.4103/0973-7847.120520.

Ayyanar M, Ignacimuthu S. 2009. Herbal medicines for wound healing among tribal people in Southern India: Ethnobotanical and scientific evidences. Int J Appl Res Nat Prod 2 (3): 29-42.

Banerjee S, Chanda A, Adhikari A, Das AK, Biswas S. 2014. Evaluation of phytochemical screening and anti inflammatory activity of leaves and stem of *Mikania scandens* (L.) wild. Ann Med Health Sci Res 4 (4): 532-536. DOI: 10.4103/2141-9248.139302.

Basumatary SK, Ahmed M, Deka SP. 2004. Some medicinal plant leaves used by the Boro (tribal) people of Goalpara District, Assam. Nat Prod Radiance 3 (2): 88-90.

Bechtold T, Mussak R. 2009. Handbook of Natural Colorants. John Wiley & Sons Ltd., United Kingdom. DOI: 10.1002/9780470744970.

Begun S, Raza SM, Siddiqui BS, Siddiqui S.1995. Triterpenoids from the aerial parts of *Lantana camara*. J Nat Prod 58: 570-1574. DOI: 10.1021/np50124a014.

Bharali R, Bharali L, Borkotoky D, Singh RK. 2017. Ethno medicinal plants used in traditional health care by Chakhesang Tribe of Phek district. Bull Environ Pharmacol Life Sci 6 (1): 46-49.

Bhardwaj S, Gakhar S. 2005. Ethnomedicinal plants used by the tribals of Mizoram to cure cuts & wounds. Indian J Tradit Knowl 4 (1): 75-80.

Bhattacharjee M, Sema YV, Pratim Sarma M. 2019. Study on multipotent medicinal aspects of *Schima Wallichii* (Bark) from Nagaland, NE, India. Asian J Pharm Clin Res 12 (3): 155-158. DOI: 10.22159/ajpcr.2019.v12i3.29288.

Bhuyan SI, Meyiwapangla, Laskar I. 2014. Indigenous knowledge and traditional use of medicinal plants by four major tribes of Nagaland, North East India. Intl J Innov Sci Eng Technol 1 (6): 481-484.

Bigoniya P, Rana AC. 2007. Wound healing activity of Euphorbia neriifolia leaf ethanolic extract in rats. J Nat Remed 7: 94-101.

Bischoff M, Kinzl L, Schmelz A. 1999. The complicated wound. Unfallchirurg 102: 797-804. DOI:10.1007/s001130050483.

Blumenthal M, Goldberg A, Brinckmann J. 2001. Herbal Medicine: Expanded Commission E Monographs. Integrative Medicine Communications, American Botanical Council, Austin, TX, Boston.

Boericke W. 1998. Pocket Manual of Homoeopathic Material Medica. B. New Delhi, India: Jain Publishers Pvt. Ltd. India.

Broughton G, Janis JE, Attinger CE. 2006: The basic science of wound healing. Plast Reconstr Surg 117 (7suppl): 12S-34S. DOI: 10.1097/01.prs.0000225430.42531.c2.

Can NM, Thao DTP. 2020. Wound healing activity of *Crassocephalum crepidioides* (Benth.) S. Moore. leaf hydroethanolic extract. Oxid Med Cell Longev 2020: 2483187. DOI: 10.1155/2020/2483187.

Chandrasekar S, Bhanumathy M, Pawar A, Somasundaram T. 2010. Phytopharmacology of *Ficus religiosa*. Pharmacogn Rev 4 (8): 195-199. DOI: 10.4103/0973-7847.70918.

Chandrasekar S, Bhanumathy M, Pawar A, Somasundaram T. 2010. Phytopharmacology of *Ficus religiosa*. Pharmacogn Rev 4 (8): 195. DOI: 10.4103/0973-7847.70918.

Chauhan BS, Johnson DE 2009. Germination, emergence and dormancy of *Mimosa pudica*. Weed Biol Manag 9 (1): 38-45. DOI: 10.1111/j.1445-6664.2008.00316.x.

Chauhan K, Patel A, Patel M, Macwan C, Solanki R, Adeshara S. 2010. *Paederia foetida* Linn. As a potential medicinal plant : A review. J Pharm Res 3 (12): 3135-3137.

Choudhury S, Ghosh P, Sarkar T, Poddar S, Sarkar A, Chatterjee S. 2020. Morphological features, phytochemical, and pharmacological study of *Leucas aspera* (Lamiaceae): A brief review. Intl J Pharmacogn Phytochem Res 12 (3): 132-137.

Chung KT, Wong TY, Wei C-I, Huang Y-W, Lin Y. 1998. Tannins and human health: A review. Crit Rev Food Sci Nutr 38 (6): 421-464. DOI: 10.1080/10408699891274273.

Das S, Choudhury MD. 2012. Ethnomedicinal uses of some traditional medicinal plants found in Tripura. Ind J Med Pl Res 6 (35): 4908-4914. DOI:10.5897/JMPR10.539.

Dash G, Murthy PN. 2011. Wound healing effects of *Ageratum conyzoides* Linn. Intl J Pharm Biol Sci 2: 369-383. DOI: 10.5402/2011/847980.

Day MD, Wiley CJ, Playford J, Zalucki MP. 2003. *Lantana*: Current Management, Status and Future Prospects. Australian Centre for International Agricultural Research, Canberra. (No. 435-2016-33733).

De Wet H, Nciki S, van Vuuren SF. 2013. Medicinal plants used for the treatment of various skin disorders by a rural community in northern Maputaland, South Africa. J Ethnobiol Ethnomed 9 (1): 791-794. DOI: 10.1186/1746-4269-9-51.

Debbarma M, Nazir A Pala, Munesh K, Rainer W Bussmann. 2017. Traditional knowledge of medicinal plants in tribes of Tripura in northeast, India. Afr J Tradit Complement Altern Med 14 (4): 156-168. DOI: 10.21010/ajtcam.v14i4.19.

Deena MJ, Thoppil JE. 2000. Antimicrobial activity of the essential oil of Lantana camara. Fitoterapia 71: 453-455. DOI: 10.1016/S0367-326X(00)00140-4.

Degreef H. 1998. How to heal a wound fast. Dermatol Clin 16: 365-375. DOI: 10.1016/s0733-8635(05)70019-x.

Devi PM, Siril EA. 2014. Traditional and modern use of Indian Madder (*Rubia cordifolia* L.): An overview. Intl J Pharm Sci Rev Res 25: 154-164.

DiPietro LA. 1995. Wound healing: The role of the macrophage and other immune cells. Shock 4: 233-240. DOI: 10.1097/00024382-199510000-00001.

Dorai AA. 2012. Wound care with traditional, complementary and alternative medicine. Indian J Plast Surg 45 (2): 418-424. DOI: 10.4103/0970-0358.101331.

Egamberdieva D, Wirth S, Behrendt U, Ahmad P, Berg G. 2017. Antimicrobial activity of medicinal plants correlates with the proportion of antagonistic endophytes. Front Microbiol 8: 199. DOI: 10.3389/fmicb.2017.00199.

Ejaz S, Chekarova I, Cho JW, Lee SY, Ashraf S, and Lim CW. 2009. Effect of aged garlic extract on wound healing: A new frontier in wound management. Drug Chem Toxicol 32 (3): 191-203. DOI: 10.1080/01480540902862236.

Emeruwa A. 1982. Antibacterial substance from *Carica papaya* fruit extract. J Nat Prod 45: 132-137. DOI:10.1021/np50020a002.

Farah DS, Kadhim MI, Waleed HY. 2018. Assessment of *Lantana camara* L. leaf extract in wound healing in induced rabbits skin injuries. Intl J Sci Res 7 (1): 448-452. DOI:10.21275/ART20178582.

Fitridge R, Thompson M. 2011. Mechanisms of Vascular Disease: A Reference Book for Vascular Specialists [Internet]. University of Adelaide Press; Adelaide (AU), Australia. DOI: 10.1017/UPO9781922064004.

Gailit J, Clark RA. 1994. Wound repair in the context of extracellular matrix. Curr Opin Cell Biol 6 (5): 717-25. DOI: 10.1016/0955-0674(94)90099-x.

Galabuzi C, Agea JD, Fungo BL, Kamoga RMN. 2010. Traditional medicine as an alternative form of health care system: A preliminary case study of Nangabo sub-county, Central Uganda. Afr J Tradit Complement Alternat Med 7:11-16. DOI: 10.4314/ajtcam.v7i1.57224.

Gaur K, Rana AC, Nema RK, Kori ML, Sharma CS. 2009. Anti-inflammatory and analgesic activity of hydro-alcoholic leaves extract of *Euphorbia neriifolia* Linn. Asian J Pharm Clin Res 2: 26-29. DOI: 10.4103/0973-8258.44735.

Ghisalberti EL. 2000. *Lantana camara* Linn. (review). Fitoterapia 71: 467-485. DOI: 10.1016/s0367-326x(00)00202-1.

Gohil KJ, Patel JA, Gajjar AK. 2010. Pharmacological review on *Centella asiatica*: A potential herbal cure-all. Indian J Pharm Sci 72 (5): 546-556. DOI: 10.4103/0250-474X.78519.

Gonçalves RF, Silva AM, Silva AM, Valentão P, Ferreres F, Gil-Izquierdo A, Silva JB, Santos D, Andrade PB. 2013. Influence of taro (*Colocasia esculenta* L. Shott) growth conditions on the phenolic composition and biological properties. Food Chem 15; 141 (4): 3480-5. DOI: 10.1016/j.foodchem.2013.06.009.

Grace OM, Simmonds MSJ, Smith GF, Van Wyk AE. 2008. Therapeutic uses of *Aloe* L. (Asphodelaceae) in Southern Africa. J Ethnopharmacol 119: 3: 604-614. DOI: 10.1016/j.jep.2008.07.002.

Grubben G, Denton OA. 2004. Plant Resources of Tropical Africa 2: Vegetables, Backhuys Publishers, Netherlands.

Hashemi SA, Abdollah MSA, Abediankenari S. 2015. The review on properties of *Aloe vera* in healing of cutaneous wounds. BioMed Res Intl 2015: 1-6. DOI: 10.1155/2015/714216.

Hemarana K, Jeyashree KV, Babu M, Kannan M. 2014. Preliminary bioactive compounds screening and antibacterial activity of methanolic extract of *Hibiscus rosa-sinensis* against selected skin pathogens. Res J Pharmac Biol Chem Sci 5 (2): 1210-1218.

Ide N, Lau BH. 1997. Garlic compounds protect vascular endothelial cells from oxidized low density lipoprotein-in-duced injury. J Pharm Pharmacol 49: 908-911. DOI: 10.1111/j.2042-7158.1997.tb06134.x.

Ide N, Lau BH. 1999a. Aged garlic extract attenuates intracellular oxidative stress. Phytomedicine 6: 125-131. DOI: 10.1016/S0944-7113(99)80047-6.

Ide N, Lau BH. 1999b. S-allylcysteine attenuates oxidative stress in endothelial cells. Drug Dev Ind Pharm 25: 619-624. DOI: 10.1081/ddc-100102217.

Jain PK, Das D, Pandey N, Jain P. 2016. Traditional Indian herb *Emblica officinalis* & its medicinal importance. Innov J Ayurvedic Sci 4 (4): 1-15.

Jamir TT, Sharma HK, Dolui AK. 1999. Folklore medicinal plants of Nagaland, India. Fitoterapia 70 (4): 395-401. DOI: 10.1016/S0367-326X(99)00063-5.

Joharapurkar AA, Zambad SP, Wanjari MM, Umathe SN. 2003. In vivo evaluation of antioxidant activity of alcoholic extract of *Rubia cordifolia* Linn. and its influence on ethanol-induced immunosuppression. Indian J Pharmacol 35: 232-236.

Joseph B, George J, Mohan J. 2013. Pharmacology and traditional uses of *Mimosa pudica*. Intl J Pharmac Sci Drug Res 5 (2): 41-44.

Kamboj VP. 2000. Herbal medicine. Curr Sci 78: 35-51. DOI: 10.5840/schoolman20007813.

Kannan S, Aravinth S, Aravinth J, Sam E, Kumar J, Kayarohanam S, Suthakaran R, Ravi M, Devi BP. 2009. Wound healing activity of *Mimosa pudica* Linn. formulation. IJPR 1 (4): 1554-1558.

Karodi R, Jadhav M, Rub R, Bafna A. 2009. Evaluation of the wound healing activity of a crude extract of *Rubia cordifolia* L. (Indian madder) in mice. Intl J Appl Res Nat Prod 2 (2): 12-18.

Kasiram K, Sakharkar P, Patil A. 2000. Antifungal activity of *Calendula officinalis*. Indian J Pharmac Sci 62: 464-466.

Khan ZA, Naqvi SA, Mukhtar A, Hussain Z, Shahzad SA, Mansha A, Ahmad M, Zahoor AF, Bukhari IH, Ashraf-Janjua MR, Mahmood N, Yar M. 2014. Antioxidant and antibacterial activities of *Hibiscus rosa-sinensis* Linn. flower extracts. Pak J Pharmac Sci 27 (3): 469-474.

Khare CP. 2004. Encyclopedia of Indian Medicinal Plants, Springer, Germany.

Khisha T, Karim R, Chowdhury SR, Banoo R. 2012. Ethnomedical studies of Chakma communities of Chittagong Hill Tracts, Bangladesh. Bangladesh Pharm J 15 (1): 59-67.

Kim Ha, Won Kyung-Jong, Kim Do, Kang Hye, Lee Hyung. 2020. Stimulatory effects of *Paederia foetida* flower absolute on the skin wound and barrier repair activities of keratinocytes. Chem Biodivers 17: 1-10. DOI: 10.1002/cbdv.202000506.

Kumar B, Vijayakumar M, Govindarajan R, Pushpangadan P. 2007. Ethnopharmacological approaches to wound healing--exploring medicinal plants of India. J Ethnopharmacol 1 114 (2): 103-113. DOI: 10.1016/j.jep.2007.08.010.

Kumar S, Malhotra R, Kumar D. 2010. *Euphorbia hirta*: Its chemistry, traditional and medicinal uses, and pharmacological activities. Pharmacogn Rev 4: 58. DOI: 10.4103/0973-7847.65327.

Kumar S, Yadav A, Yadav M. 2017. Effect of climate change on phytochemical diversity, total phenolic content and in vitro antioxidant activity of *Aloe vera* (L.) Burm.f.. BMC Res Notes 10: 60. DOI: 10.1186/s13104-017-2385-3.

Kumarasamayraja D, Jeganathan NS, Manavalan R. 2012. A review on medicinal plants with potential wound healing activity. Intl J Pharm Sci 2 (4): 105-111.

Ladeira, Zaidan AM, Figueiredo-Ribeiro RCL. 1987. *Ageratum conyzoides* L. (compositae): Germination, flowering and occurrence of phenolic derivatives at different stages of development. Hoehnea 15: 53-62.

Lalrinzuali K, Vabeiryureilai M, Chandra G. 2015. Ethnomedicinal use and phytochemical analysis of selected medicinal plants of Mizoram India. Trends Green Chem 1: 1-9. DOI: 10.21767/2471-9889.100009.

Lam KY, Ling APK, Koh RY, Wong YP, Say YH. 2016. A review on medicinal properties of orientin. Adv Pharmacol Sci 2016: 4104595. DOI: 10.1155/2016/4104595.

Lemmens R, Bunyapraphatsara N. 2003. Plant Resources of South-East Asia: Medicinal and Poisonous Plants, Backhuys Publishers, Leiden.

Li J, Zhang YP, Kirsner RS. 2003. Angiogenesis in wound repair: Angiogenic growth factors and the extracellular matrix. Microsc Res Tech 60: 107-114. DOI: 10.1002/jemt.10249.

Li X, Wang C, Xiao J, McKeehan WL, Wang F. 2016. Fibroblast growth factors, old kids on the new block. Semin Cell Dev Biol 53: 155-167. DOI: 10.1016/j.semcdb.2015.12.014.

Liu C, Leung MYK, Koon JCM. 2006. Macrophage activation by polysaccharide biological response modifier isolated from *Aloe vera* L. var. chinensis (Haw.) Berg. Intl Immunopharmacol 6 (11): 1634-1641. DOI: 10.1016/j.intimp.2006.04.013.

Liu M, Dai Y, Li Y, Luo Y, Huang F, Gong Z, Meng Q. 2008. Madecassoside isolated from *Centella asiatica* herbs facilitates burn wound healing in mice. Planta Medica 74 (08): 809-815. DOI: 10.1055/s-2008-1074533.

Loi DT. 2004. Glossary of Vietnamese Medicinal Plants, Medical Publishing House, Ha Noi, Vietnam.

Lordani TVA, De Lara CE, Ferreira FBP, De Souza Terron Monich M, Da Silva CM, Lordani CRF, Bueno FG, Teixeira JJV, Lonardoni MVC. 2018. Therapeutic effects of medicinal plants on cutaneous wound healing in humans: A systematic review. Mediators Inflamm 2018: 1-12. DOI: 10.1155/2018/7354250.

Majumdar K, Datta BK. 2007. A study on ethnomedicinal usuage of plants among the folklore herbalists and Tripuri medicinal practitioners. Part II. Nat Prod Rad 6 (1): 66-73.

Makhijia IK, Sharma IP, Khamar D. 2010. Phytochemistry and Pharmacological properties of *Ficus religiosa*: An overview. Ann Biol Res 1 (4): 171-180.

Maquart FX, Chastang F, Simeon A, Birembaut P, Gillery P, Wegrowski Y. 1999. Triterpenes from *Centella asiatica* stimulate extracellular matrix accumulation in rat experimental wounds. Eur J Dermatol 9 (4): 289-296.

Maria L, Parente L, Souza R de, Lino J, Manrique L, Tresvenzol F, Vinaud MC, Paula R de, Paulo NM. 2012. Wound healing and anti-inflammatory effect in animal models of *Calendula officinalis* L. growing in Brazil. Evid-Based Complement Alternat Med 2012: 1-7. DOI: 10.1155/2012/375671.

Marks MK, Nwachuku AC. 1986. Seed-bank characteristics in a group of tropical weed. Weed Res 26 (3): 151-157. DOI: 10.1111/j.1365-3180.1986.tb00690.x.

Matos FJA. 1988. Plantas medicinais: Boldo, Colônia e Mentrasto. O Povo, Univ. Aberta, Fortaleza.

Ming LC. 1999. *Ageratum conyzoides*: A tropical source of medicinal and agricultural products. Perspectives on New Crops and New Uses 1988: 469-473.

Missoum A. 2018. An update review on *Hibiscus* and medicinal uses. J Ayudervic Her Med 4 (3): 135-146. DOI: 10.31254/jahm.2018.4308.

Nafiu AB, Rahman MT. 2015. Anti-inflammatory and antioxidant properties of unripe papaya extract in an excision wound model. Pharmac Biol 53 (5): 662-671. DOI: 10.3109/13880209.2014.936470.

Nagori PB, Solanki R. 2011. Role of medicinal plants in wound healing. Res J Med Plants 5: 392-405. DOI: 10.3923/rjmp.2011.392.405.

Nayak BS, Marshall JR, Isitor G. 2010. Wound healing potential of ethanolic extract of *Kalanchoe pinnata* Lam. leaf—A preliminary study. Indian J Exp Biol 48 (6): 572-576.

Nayak BS, Raju SS, Eversley M, Ramsubhag A. 2009. Evaluation of wound healing activity of *Lantana camara* L.-a preclinical study. Phytother Res 23 (2): 241-245. DOI: 10.1002/ptr.2599.

Nayak BS, Raju SS, Orette FA, Rao CVA. 2007. Effects of *Hibiscus rosa-sinensis* L (Malvaceae) on wound healing activity: A preclinical study in a sprague dawley rat. Intl J Low Extrem Wounds 6 (2): 76-81. DOI: 10.1177/1534734607302840.

Nayak BS, Ramdeen R, Adogwa A, Ramsubhag A, Marshall JR. 2012. Wound-healing potential of an ethanol extract of *Carica papaya* (Caricaceae) seeds. Intl Wound J 9 (6): 650-655. DOI: 10.1111/j.1742-481X.2011.00933.x.

Nelia L, Limasenla. 2020. Traditional knowledge of medicinal plants used by the Chakhesang Naga Tribe in Phek District of Nagaland, India. Pleione 14: 237-247. DOI:10.26679/Pleione.14.2.2020.237-247.

O'Toole EA. 2001. Extracellular matrix and keratinocyte migration. Clin Exp Dermatol 26 (6): 525-30. DOI: 10.1046/j.1365-2230.2001.00891.x.

Oboh G, Olabiyi AA, Akinyemi AJ. 2013. Inhibitory effect of aqueous extract of different parts of unripe pawpaw (*Carica papaya*) fruit on Fe2+-induced oxidative stress in rat pancreas in vitro. Pharm Biol 51 (9): 1165-1174. DOI: 10.3109/13880209.2013.782321.

Osman H, Rahim AA, Isa NM, Bakhir NM. 2009. Antioxidant activity and phenolic content of *Paederia foetida* and *Syzygium aqueum*. Molecules 14 (3): 970-978. DOI: 10.3390/molecules14030970.

Owokotomo AI, Ekundayo O, Oladosu IA, Aboaba SA. 2012. Analysis of the essential oils of leaves and stems of *Crassocephalum crepidioides* growing in south Western Nigeria. Intl J Chem 4 (2): 34-37. DOI: 10.5539/ijc.v4n2p34.

Owoyele BV, Adebukola OM, Funmilayo AA, Soladoye AO. 2008. Anti-inflammatory activities of ethanolic extract of Carica papaya leaves. Inflammopharmacol 16 (4): 168-173. DOI: 10.1007/s10787-008-7008-0.

Pandurangan A, Kavita R, Apoorva S. 2015. Evaluation of antimicrobial and anthelmentic activity of leaves of *Chromolaena odorata*. Intl Bull Drug Res 5: 64-71.

Panyaphu K, On TV, Sirisa-Ard P, Srisa-Nga P, ChansaKaow S, Nathakarnkitkul S 2011: Medicinal plants of the Mien (Yao) in Northern Thailand and their potential value in the primary healthcare of postpartum women. J Ethnopharmacol 135: 226-237. DOI: 10.1016/j.jep.2011.03.050.

Pereira PR, Silva JT, Verícimo MA, Paschoalin VMF, Teixeira GAPB. 2015. Crude extract from taro (*Colocasia esculenta*) as a natural source of bioactive proteins able to stimulate haematopoietic cells in two murine models. J Funct Foods 18 (Part A): 333-43. DOI: 10.1016/j.jff.2015.07.014.

Policepatel SS, Manikrao VG. 2013. Ethnomedicinal plants used in the treatment of skin diseases in Hyderabad Karnataka region, Karnataka, India. Asian Pac J Trop Biomed 3 (11): 882-886. DOI: 10.1016/S2221-1691(13)60173-2.

Purohit SK, Solanki R, Soni M, Mathur V. 2012. Experimental evaluation of *Aloe vera* leaves pulp as topical medicament on wound healing. Intl J Pharmacol Res 2: 110-112. DOI: 10.7439/ijpr.v2i3.702.

Putra KWE, Pitoyo A, Nugroho GD, Rai M, Setyawan AD. 2020. Review: Phytochemical activities of *Ficus* (Moraceae) in Java Island, Indonesia. Bonorowo Wetlands 10: 98-125. DOI: 10.13057/bonorowo/w100204.

Rahim ZB, Rahman MM, Saha D, Hosen SMZ, Paul S, Kader S. 2012. Ethnomedicinal plants used against jaundice in Bangladesh and its economical prospects. Bull Pharm Res 2 (2): 91-105.

Rai PK, Lalramnghinglova H. 2010. Ethnomedicinal plant resources of Mizoram, India: Implication of traditional knowledge in health care system. Ethnobot Leafl 14: 274-305.

Ranibala DL, Das A. 2015. Study on the medicinal plants used for dermatological healthcare management practices by the Paite Tribe of Manipur, India. Intl J Innov Res Sci Technol 1 (10): 192-196.

Rashmi V, Sahu P. 2020. Ethenoecological studies of *Oxalis corniculata*: A updated review. Intl J Anal Exp Modal Anal 12: 660-665.

Rehecho S, Uriarte-Pueyo I, Calvo J, Vivas LA, Calvo MI. 2011. Ethnopharmacological survey of medicinal plants in Nor-Yauyos, a part of the Landscape Reserve Nor-Yauyos-Cochas, Peru. J Ethnopharmacol 133: 75-78. DOI: 10.1016/j.jep.2010.09.006.

Rivera-Pastrana DM, Yahia EM, Gonza´lez-Aguilar GA. 2010. Identification of phenolic and carotenoid compounds in *Carica papaya* L. 'Maradol' using liquid chromatography-Mass spectrometry. Acta Hort 877: 1197-1204. DOI: 10.17660/ActaHortic.2010.877.163.

Robson MC, Steed DL, Franz MG. 2001. Wound healing: Biologic features and approaches to maximize healing trajectories. Curr Probl Surg 38: 72-140. DOI: 10.1067/msg.2001.111167.

Rout J, Sajem AL, Nath M. 2010. Traditional medicinal knowledge of the Zeme (Naga) Tribe of North Cachar Hills District, Assam on the treatment of diarrhoea. Assam University J Sci Tech: Biol Environ Sci 5 (1): 63-69.

Roy K, Shivakumar H, Sarkar S. 2009. Wound healing potential of leaf extracts of *Ficus Religiosa* on wistar albino strain rats. Intl J Pharm Tech Res 1 (3): 506-508.

Rufatto LC, Gower A, Schwambach J, Moura S. 2012. Genus *Mikania*: Chemical composition and phytotherapeutical activity. Braz J Pharmacogn 22 (6): 1384-1403. DOI: 10.1590/s0102-695x2012005000099.

Ryu K, Ide N, Matsuura H, Itakura Y. 2001. N alpha-(1-de-oxy-D-fructos-1-yl)-L-arginine, an antioxidant compound identified in aged garlic extract. J Nutr 131: 972S-976S. DOI: 10.1093/jn/131.3.972S.

Saha MR, Sarker DD, Sen A. 2014. Ethnoveterinary practices among the tribal community of Malda District of West Bengal, India. Indian J Tradit Knowl 13 (2): 359-367.

Saini S, Dhiman A, Nanda S. 2016. Traditional indian medicinal plants with potential wound healing activity: A review. Intl J Pharm Sci Res 7 (5): 1809-1819. DOI: 10.13040/IJPSR.0975-8232.7(5).1809-19.

Santiago JL, Galan EM-Moya, Muñoz JR-Rodriguez, MAngel de la C-Morcillo, Redondo FJ-Calvo, GraciaI-Fernandez, Peter M Elias, Perez JM-Ortiz, Mao-Qiang Man. 2020. Topical applications of thiosulfinate-enriched *Allium sativum* extract accelerates acute cutaneous wound healing in murine model. Chinese J Integr Med 26 (11): 812-818. DOI: 10.1007/s11655-020-3086-7.

Sathi S, Kalyan MS, Chowdhury HR. 2015. Anato-pharmacognostic studies of *Mikania micrantha* Kunth: A promising medicinal climber of the family Asteraceae. Intl J Res Ayurveda Pharm 6 (6): 773-780. DOI: 10.7897/2277-4343.066144.

Saxena M, Saxena J, Nema R, Singh D, Gupta A. 2013. Phytochemistry of medicinal plants. J Pharmacogn Phytochem 1 (6): 168-182.

Saxena M, Saxena J, Sarita K. 2012. A brief review on: Therapeutical values of *Lantana camara* plant. Intl J Pharm Life Sci 3 (3): 1551-1554.

Saxena RC, Dixit OP, Harshan V. 1992. Insecticidal action of *Lantana camara* against *Callosobruchus chinensis* (Coleoptera Bruchidae). J Stored Pro Res 53: 230-235. DOI: 10.1016/0022-474X(92)90009-F.

Sharma S, Singh A, Sharma OP. 1999. An improved procedure for isolation and purification of lantadene A, the bioactive pentacyclic triterpenoid from *Lantana camara* leaves. J Med Arom Plant Sci 21: 686-688.

Shedoeva A, Leavesley D, Upton Z, Fan C. 2019. Wound healing and the use of medicinal plants. Evid-Based Complement Alternat Med 2019: 2684108. DOI: 10.1155/2019/2684108.

Shen HM, Chen C, Jiang JY, Zheng YL, Cai WF, Wang B, Ling Z, Tang L, Wang YH, Shi GG. 2017. The N-butyl alcohol extract from *Hibiscus rosa-sinensis* L. flowers enhances healing potential on rat excisional wounds. J Ethnopharmacol 198: 291-301. DOI: 10.1016/j.jep.2017.01.016.

Sidik K, Mahmood AA, Salmah I. 2006. Acceleration of wound healing by aqueous extract of *Allium sativum* in combination with honey on cutaneous wound healing in rats. Intl J Mol Med Adv Sci 2 (2): 231-235.

Singh M, Sharma PHR, Mollier RT, Ngullie E, Kumar Baisyha S, Rajkhowa DJ. 2019. Tribal farmers' traditional knowledge and practices for pig farming in Nagaland. Indian J Anim Sci 89 (3): 329-333.

Somboonwong J, Kankaisre M, Tantisira M, Tantisira MH. 2012. Wound healing activities of different extracts of Centella asiatica in incision and burn wound models: An experimental animal study. BMC Complement Alternat Med 12:103. DOI: 10.1186/1472-6882-12-103.

Srinivasan R, Ravali B, Suvarchala P, Honey A, Tejaswini A, Neeraja P. 2011. *Leucas aspera*-medicinal plant: A review. Intl J Pharm Biosci 2 (1): 153-159.

Suganthy R, Karunya PA, Sivashangari D, Geetha K. 2020. Wound healing potential of Indian traditional tree-*Ficus religiosa*. Inl. J Future Gener Commun Netw13 (1): 1221-1229.

Tarameshloo M, Norouzian M, Zarein-Dolab S, Dadpay M, Mohsenifar J, Gazor R. 2012. *Aloe vera* gel and thyroid hormone cream may improve wound healing in Wistar rats. Anat Cell Biol 45 (3): 170-177. DOI: 10.5115/acb.2012.45.3.170.

Thorat BR, Bolli V. 2017. Review on *Euphorbia neriifolia*. Plant Biomed J Sci Tech Res 1 (6): 1723-1732. DOI: 10.26717/BJSTR.2017.01.000523.

Tiwari NN, Joshi MP. 1990. Medicinal plants of Nepal: Volumes I, II and III. J Nepal Med Assoc 28: 181-190, 221-232, 266-279.

Tripathi AK, Limasenla, Shankar R. 2017. Ethno-medicinal plants used by Nyishi Tribe of Arunachal Pradesh, India. World J Pharm Pharm Sci 1246-1253. DOI: 10.20959/wjpps20175-9213.

Tripathi SC, Srivastava M. 2010. Ethnomedicinal flora of Euphorbiaceae used in dermatological problems. Indian J Tradit Knowl 9 (2): 318-320. DOI: 10.7763/IJESD.2010.V1.62.

Tripathi YB, Sharma M. 1998. Comparison of antioxidant action of the alcoholic extract of *Rubia cordifolia* with Rubiadin. Indian J Biochem Biophysics 35 (5): 313-316.

Tuhin RH, Begum MM, Rahman MS, Karim R, Begum T, Ahmed SU, Mostofa R, Hossain A, Abdel-Daim M, Begum R. 2017. Wound healing effect of *Euphorbia hirta* Linn. (Euphorbiaceae) in alloxan induced diabetic rats. BMC Complement Altern Med 17 (1): 423. DOI: 10.1186/s12906-017-1930-x.

Ukiya M, Akihisa T, Yasukawa K, Tokuda H, Suzuki T, Kimura Y. 2006. Anti-inflammatory, anti-tumor-promoting, and cytotoxic activities of constituents of marigold (*Calendula officinalis*) flowers. J Nat Prod 69: 1692-1696. DOI: 10.1021/np068016b.

Vaisakh MN, Pandey A. 2012. The invasive weed with healing properties: A review on *Chromolaena odorata*. Intl J Pharm Sci Res 3: 80-83.

Vastrad JV, Byadgi SA. 2018. Phytochemical screening and antibacterial activity of *Hibiscus rosa-sinensis* leaf extracts. Intl J Curr Microbiol Appl Sci 7 (3): 3329-3337. DOI: 10.20546/ijcmas.2018.703.384.

Velayudhan KC, Dikshit N, Abdul Nizar M. 2012. Ethnobotany of turmeric (*Curcuma longa* L.). Indian J Tradit Knowl 11 (4): 607-614.

Velnar T, Bailey T, Smrkolj V. 2009. The wound healing process: An overview of the cellular and molecular mechanisms. J Intl Med Res 37: 1528-1542. DOI: 10.1177/147323000903700531.

Verma RK, Verma SK. 2006. Phytochemical and termiticidal studies of *Lantana camara* var *aculeata* leaves. Fitoterapia 77: 466-468. DOI: 10.1016/j.fitote.2006.05.014.

Wadood A, Ghufran M, Babar Jamal S, Naeem M, Khan A, Ghaffar R, Asnad. 2013. Phytochemical analysis of medicinal plants occurring in local area of Mardan. Anal Biochem 2 (4): 1000144. DOI: 10.4172/2161-1009.1000144.

World Health Organization. Traditional medicine: Fact sheet N134. 2008. Dec, [Last accessed on 2012 Apr 15]. Available from: http://www.who.int/mediacentre/factsheets/fs134/en/.

Yadav Y.C. 2015. Hepatoprotective effect of *Ficus religiosa* latex on cisplatin induced liver injury in wistar rats. Rev Bras Farm 25: 278-283. DOI: 10.1016/j.bjp.2015.03.012.

Yao LH, Jiang YM, Shi J, Tomás-Barberán FA, Datta N, Singanusong R. 2004. Flavonoids in food and their health benefits. Plant Foods Hum Nutr 59 (3): 113-122. DOI: 10.1007/s11130-004-0049-7.

Yoshikawa M, Murakami T, Kishi A, Kageura T, Matsuda H. 2001. Medicinal flowers. III. Marigold. (1): Hypoglycemic, gastric emptying inhibitory, and gastroprotective principles and new oleanane-type triterpene oligoglycosides, calenda saponins A, B, C, and D, from Egyptian *Calendula officinalis*. Chem Pharm Bull 49: 863-870. DOI: 10.1248/cpb.49.863.

Yuhlung CC, Bhattacharyya M. 2016. Indigenous medicinal plants used by the Maring Tribe of Manipur, Northeast India. J Ayurvedic Herb Med 2 (4): 146-153. DOI: 10.31254/jahm.2016.2410.

Zhasa NN, Hazarika P, Tripathi YC. 2015. Indigenous knowledge on utilization of plant biodiversity for treatment and cure of diseases of human beings in Nagaland, India: A case study. Intl Res J Biol Sci 4 (4): 89-106.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 5, Number 2, November 2022 E-ISSN: 2580-4510
Pages: 121-129 DOI: 10.13057/asianjethnobiol/y050205

Ethnobotanical survey of plants used by the riparian population of Banco National Park (Abidjan, Ivory Coast)

ERIC GNAHORE[1,♥], KOUASSI RICHARD KOUADIO[2], ACHIEDO JEAN GREVIN AMBA[1], MOUSSA KONE[1,3], ADAMA BAKAYOKO[1,4]

[1]UFR Natural Sciences, Research Unit in Ecology and Biodiversity, Laboratory of Ecology and Sustainable Development, Nangui Abrogoua University. 02 PO. Box 801, Abidjan 02, Republic of Ivory Coast. Tel./fax.: +2250505599639, ♥email: gnahoreeric136@yahoo.com
[2]Researcher at National Center for Agricultural Research, Forest Program and Environment, Station of Cocody, 08 PO. Box 33, Abidjan 08, Republic of Ivory Coast
[3]Aké-Assi Botanical Institute of Andokoi. 08 PO. Box 172, Abidjan 08, Republic of Ivory Coast
[4]Swiss Center for Scientific Research in Ivory Coast. 01 PO. Box 1303, Abidjan 01, Republic of Ivory Coast

Manuscript received: 3 August 2022. Revision accepted: 16 September 2022.

Abstract. *Gnahore E, Kouadio KR, Amba AJG, Kone M, Bakayoko A. 2022. Ethnobotanical survey of plants used by the riparian population of Banco National Park (Abidjan, Ivory Coast). Asian J Ethnobiol 5: 121-129.* Situated at the "heart" of Abidjan, Banco National Park (BNP), Ivory Coast, is the rare relics of moist, dense rainforests coveted everywhere. This work was undertaken with an aim of identifying the plants most usually used by the riparian population of BNP in human food, animal food, and pharmacopeia. An ethnobotanical survey was carried out of the riparian population of the BNP. The method consists of an ethnobotanical survey realized among the inhabitants of the park and those of the surrounding urban districts. The method used was semi-structured interviews. This study targeted 294 people, including 20% men and 80% women, aged between 30 and 60. A total of 36 plant species from 34 genera and 28 families were recorded. Thirteen species were used in food, three fodder species, and thirty others used to treat several ailments in the area. Two of these plants have strong ratio utilization in human food: *Myrianthus arboreus* P.Beauv. (15.25%) and *M. libericus* Rendle (14%). Thus, in the area study, five species are respectively considered threatened and three species rare. Leaves (32.55%) and bark (20.93%) are the most used organ. Decoction (98%) was the most common traditional medicine preparation method. Indigenous knowledge distribution in the community showed significant differences ($p<0.05$) in the study groups for factors of age, sex, gender, and educational level. The number of resources used can seriously impact the forest negatively. It is urgent to adopt a lasting management plan for sustainable harvest for the safeguard and preservation of the plant cash of the BNP.

Keywords: Banco National Park, ethnobotanical surveys, riparian population

INTRODUCTION

Tropical forest ecosystems are biodiversity reservoirs that play a fundamental role in meeting the basic needs of local communities (Agbo et al. 2017). Indeed, food, medicine and energy supply are the most important ecosystem services terrestrial ecosystems provide to local people (Ouédraogo et al. 2020). People in rural and urban areas, particularly indigenous peoples, have long used traditional health care approaches based on medicinal plants (Dogara et al. 2021). Therefore, wild food species are heavily exploited by local people to improve food security and their livelihoods causing high human pressure on savanna species (Ouédraogo et al. 2017). Ethnobotany is an interdisciplinary specialty concerned with understanding and applying plants and their ecosystems in connection with their cultural, social, and economic significance (Gaoue et al. 2017). It studies human-plant interactions at various spatial, chronological, historical, and cross-cultural scales, focusing on the cultural value of plants, how humans have used and modified plants, and how they represent plants in their knowledge systems (Mahmoud et al. 2020). Focusing on the present-day situation of ever-increasing exploitation of plants and natural resources, the main reason for showing interest in ethnobotany is its vast outcome that benefits every living being (Guissou et al. 2015). About 80% of the human population and 90% of livestock is believed to be dependent on traditional medicine and most of this comes from plants (Aragaw et al. 2020). Indeed, the anthropogenic pressures on these forest resources due to population growth are becoming increasingly important. Socio-economic characteristics of people (ethnicity, gender, age, occupation, etc.) are important factors affecting the management and use of forest resources, including preferences and valorization (Agúndez et al. 2020). Deforestation increased mainly in tropical forests due to the strong link between people's economic activities and land needs (De Sy et al. 2019). Moreover, in tropical countries where poor people's livelihoods depend strongly on forest resources, the exploitation is still done without respect to management plans. Ivory Coast is one of those countries.

In West Africa, the vegetal species are of very great importance to the rural and urban populations, a reason of their use for the satisfaction of the food needs (humans and animals), therapeutic, energizing and of service so much profit-making that on other aspects of the man's well-being (Dro et al. 2013). Urban communities in the Abidjan

region, especially those near the Banco National Park (BNP) areas, have a higher dependency on forest resource consumption. Forest resources are the source of revenue, employment, shelter, housing materials, cloth, ornament, fuel, fodder, grazing, timber, food, vegetables, medicines, fertilizer, fiber, floss, oilseed, cottage industries and handicrafts, and other non-timber forest products in the rural areas of BNP. Supply many products and non-timber forest products (leaves, flowers, fruits, seeds, barks, saps, fibers, rootstocks, etc.) by the woody multi-purpose is a perfect illustration.

However, these vegetal species and their habitats undergo some disturbances bound to this anthropogenic action and the climatic changes that threaten their survival even if their ecological, morphological, genetic characterizations and the inventory of their utility have been deepened (Adou et al. 2018). Such is the case of the BNP and her outskirts undergoing anthropogenic actions (Adou et al. 2018). This protected area was created in 1953 for biodiversity it has been conservation and been part of this network of protected areas from the Ivory Coast. Unfortunately, this protected area is infiltrated largely by the riparian population for harvesting medicinal plants, human food, and animal food plants (Adou et al. 2018). Delimited by four townships, this park undergoes the urbanization consequences of Abidjan city. This situation compromises its conservation, like many works realized on the knowledge of the utility plants collected in the forestry or savannah training by the local populations in Ivory Coast (Adou et al. 2018). This study is part of implementing a conservation strategy in the context of the degradation of the natural resources that this park is experiencing. A better knowledge of the vegetal species in place, their typology of uses as well as their state in conservation prove to be necessary. The present study's general objective conducted in the Abidjan commune was to document the medicinal, human and animal food plants mostly used by the riparian population of the BNP, their local names, and their mode of use and their various pharmacological and therapeutic uses. It is specifically about leading an ethnobotanical investigation of the riparian population, to collect, identify and characterize the vegetal species while raising their uses.

MATERIALS AND METHODS

Study area

The present research was carried out in the BNP and its outskirts are situated in Abidjan, Ivory Coast. It is between 5°21' and 5°25 North latitude and between 4°01' and 4°05' West longitude (Figure 1). It covers an area of about 3438.34 hectares and is delimited by the community of Abobo in the North, Adjamé in the East, the rural community of Attécoube in the South and the community of Yopougon in the West.

The climate in this area is sub-equatorial type, it is humid and cool in winter and mild in summer. Precipitation is characterized by non-regularity from one year to the next. The annual average precipitation is 1550 mm, while the monthly temperatures oscillate between 21°C and 31°C with an average of 26°C (Tiébre et al. 2014). Despite its relatively limited surface, the park of Banco maintains a forest microclimate. The temperature decreases superior to the bass stratum, the gap sometimes of more than 4°C. August is the hottest month of the year (Tiébre et al. 2014).

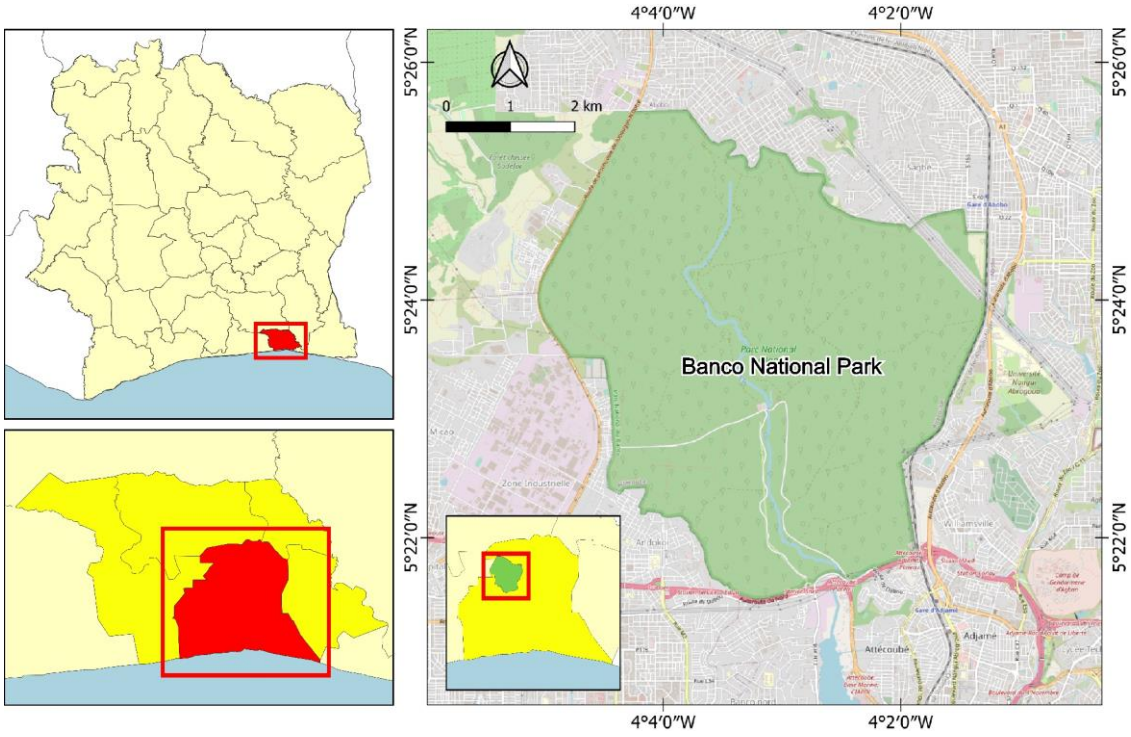


Figure 1. Geographical location of the study framework in Banco National Park, Abidjan, Ivory Coast

The relative humidity is close to the saturation, the gradient higher to soil than to the summit, with a minimum of 27% in January, the driest month (Tiébre et al. 2014). January the coldest month of the year according to the classification of (Tiébre et al. 2014), the BNP belongs to the ombrophily sector characterized by a predominance of sempervirante dense humid forest bound to abundant precipitations. The vegetation of the park of Banco is marked by a mosaic of vegetal formations, which are the most important basis of plant groups formation on the land.

The edaphic groups are situated under the dependence of water in funds of the talwegs. The anthropogenic groups or forest plantations were realized between 1925 and 1950 in the setting of the enrichment of the natural populations, or the reconstruction of the forest stand in the zones of culture or fallow.

Ethnobotany survey and data analysis

The information was obtained through ethnobotanical approaches with the people born in that area/or those who have lived in the area for a long time in the different townships near the Banco National Park (Kouakou et al. 2020).

Data collection

The ethnobotanical survey was conducted from September to December 2018. Ethnobotanical data were obtained using a semi-structured questionnaire method. The target groups for this study were herbalists, traditional medical practitioners, traditional midwives, homemakers, and other people of old age who have practiced and used medicinal and food (Human and animals) plants. The questionnaires used were divided into two parts, namely part A and B.

In part A, the socio-demographic information of the respondents was recorded, and information on plants used for traditional medicinal and food (humans and animals) was recorded in part B. Then, the local population was invited to gather the plants' samples and inform them of their mode of use and indications. Finally, the medicinal vegetal species' samples were received to validate and/or verify their local names with several investigations.

For the second part (part B), an inquiry was made to know "the extent to which food usage (mode of use) was associated with plant species" rather than asking "which plants were used for which food usages." For each mode of use cited, the name of the plants and the plant parts used were recorded. Our questionnaire data covered the respondent's backgrounds: name, age, sex, occupation, education level, habitat and distribution, major use categories, part(s) used, mode of collection, and local status. The survey was carried out with a sample size of 294 people from the population of different towns and their surroundings for four months. The women made up 80% of the total investigated population. During each interview, introverted information was obtained from the participants, the data obtained included the plants the participants used. The interviews were conducted in French, they lasted 20 to 30 minutes, during which we tried to obtain as much information on the socio-demographic profile of the people surveyed (age, sex, academic level, etc.) and the vegetal species used by them (local name, different uses, partly used, a different mode of use and diseases treated by these plants). Interviews were actualized in diversified places (farms, houses, and parks).

Collection and identification of plants specimens

Preliminary identification was done in the park. The voucher specimens which could not be identified in the park were taken to the Swiss Center for Scientific Research in Ivory Coast Herbarium and were identified using taxonomic keys and the flora of West Africa. The scientific names of the plant species were updated using relevant databases (http://www.ipni.org) and the family names were confirmed using databases (http://www.theplantlist.org) accessed on 13/05/2022.

Data analysis

Obtained informant data were analyzed by quantitative index: use value (T). The use value is a quantitative method used to demonstrate the relative importance of a species known locally. The result was processed using XLSTAT-Pro (version 7.1) software and the Excel spreadsheet. In this study, only the use value (T) was used. This measure was calculated to determine the relative importance of a particular species. The use value was calculated using the formula (Shaheen et al. 2017):

$$T\ (\%) = (Np / N) \times 100$$

Where; T denotes the use value of a species, Np is several citations per species; and N refers to the number of respondents. The range of T is 0 to 100%. The use value is high when several use reports exist for a plant, which means the plant is imperative. The use value drops to 0 when only a few use-related plant reports are found. However, T does not differentiate if a plant is used for one or more purposes (Ndiaye et al. 2017). Higher T is an indicative ratio utilization of a particular plant species for the treatment of a disease or ailment of a specific category by the informants of the studied area (Ndiaye et al. 2017).

Descriptive statistical methods (percentage and frequency) were used to summarize plant parts, mode of use, and mode of administration (Teka et al. 2020). Word 2013 software was used for data entry, and Excel 2013 for producing tables and figures. Univariate statistics were conducted to evaluate net effects. Mean differences between the paired study sites surrounding the BNP were compared with non-parametric Kruskal-Wallis matched pairs test statistics when discrete count data were analyzed. One-way ANOVAs and student t test are used to compare normally distributed data. Post-hoc comparisons were performed using the Tukey HSD tests. Non-parametric Mann-Whitney analysis was used to examine traditional knowledge differences across age class, gender and educational level. These variables determined traditional knowledge of a community (Teka et al. 2020). All statistical analyses were performed using XLSTAT-Pro (version 7.1) software.

RESULTS AND DISCUSSION

Results

Socio-participants characteristics of respondents

The informants (59 men and 235 women) were either native-born or had been living in the zone for more than 20 years. The ages of the interviewees ranged from 30 to 60 years. Most of the respondents (43.53%) were above 50 years of age. Participants reported different numbers of medicinal plants in the demographic characters considered. The statistical details showing variation in medicinal plants reported in different demographic characters are presented below.

In the region of Abidjan, both men and women use the plant species of BNP. However, women use plant species more than men (Table 1). Women listed a greater number of plant species (80%) than men with 20% (Figure 2). Mann-Whitney Test statistical analysis showed a significant knowledge difference between the two (2) gender groups on the traditional use of plant species for different purposes ($P<0.0001$).

The use of vegetal species in the study area is widespread among all the age groups, with a predominance of people in age categories 50 to 60 years (43.53%), according to Table 1. The age group of 40 to 50 years and 30 to 40 years come next with 25.85% and 30.61%, respectively (Figure 3). The average age was around forty years (40 years), the youngest was 32 years old, and the oldest was 58 years. People of at least fifty years (50 years) represent more than a third of the investigated population. However, people under 30 years did not use a lot of vegetal species. The ANOVA test showed a very significant difference in all age classes ($F=5.1$; $P<0.009$, observed in the age groups between 30 and 40 years, $F=185.486$; $P<0.0001$ for age 40 to 50 and $F=70.55$; $P<0.0001$ for age 50 to 60). In addition, a significant difference in the number of medicinal plants mentioned was found between the age groups, with a greater number of medicinal plants mentioned by older adults (above 50 years) than young ones (30-50 years) (ANOVA test Test, $p<0.05$).

In our study area, a large proportion of vegetal species users were illiterate, 52.63% (Table 1). Nevertheless, people with primary school education had an average percentage of medicinal plant use of 47.37% (Figure 4). However, statistical analysis of the educated showed that this percentage varied significantly ($F=4.93$; $P=0.009$). Similarly, the proportion was significantly different among those illiterate ($F=4.31$; $P=0.015$). Educational levels also showed significant differences in the illiterates cited more plants than educated informants. On average, more medicinal plants were cited by men, but the statistical analysis showed a significant difference ($p<0.05$). However, the presence of gender-specific knowledge was reported.

According to Table 1, the family's situation was very important in using plants: 56.76% of single people used plants against 43.24% of married people. In addition, 42.20% of people were cited as housewives, 110 (37.60%) as traders, and 59 (20.20%) people from mechanics.

Plant used by the riparian population of BNP

Human foods plant used

The present study shows that 13 vegetal species (35.13%) were used in human food (Table 2). These picking products constitute an important source, less expensive and easily accessible to the population. Table 2 lists species used in human food and their usage rates throughout the survey. Two (2) of these plants have strong ratio utilization: *Myrianthus arboreus* P.Beauv. (15.25%) and *M. libericus* Rendle (14%). The dominant harvest type was picking (63.51%) followed by stripping (23.07%) and uprooting with 15.38% (Figure 5). The plant name, the plant family, the used part, the type of harvest, and the use rates are shown in Table 2 and medicinal plant species and their uses are shown in Table 3.

Rare and threatened species at the survey level

It is clear that the vegetal species contribute to improving the conditions of life of the populations, but uses are not without consequence on the sustainability of these resources. This is how it was cited as threatened species because of the high frequency of use but recognized by the riparian population for these virtues. According to this study, threatened species are *Panicum maximum* Jacq., *Ficus exasperata* Vahl, *Microdesmis keayana* J.Léonard, *Strombosia pustulata* Oliv. and *Bambusa vulgaris* Schrad. ex J.C.Wendl.. The species cited by the population but rarely listed in the inventory is *Annickia polycarpa* (DC.) Setten & Maas ex I.M.Turner, *Newbouldia leavis* (P.Beauv.) Seem and *Buchholzia coriacea* Engl. In this way, the main causes are illegal cuts (14.4%), skinning (55.6%), uprooting (12.9%), and stripping (17.1%).

Figure 2. Distribution of plant users by sex

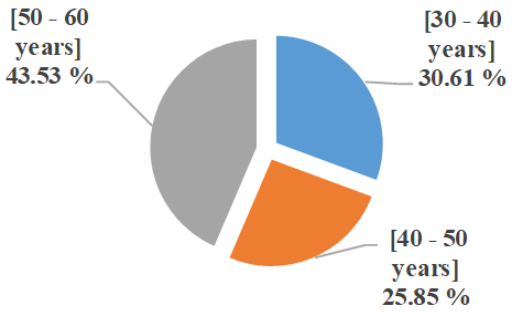


Figure 3. Distribution of plant users by age

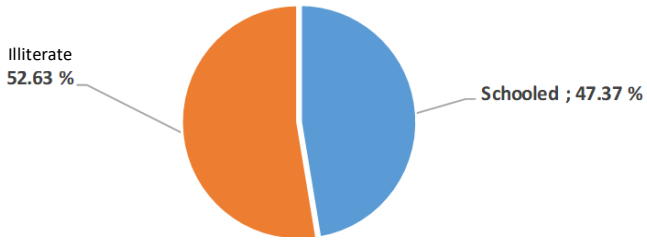


Figure 4. Distribution of plant users by grade level

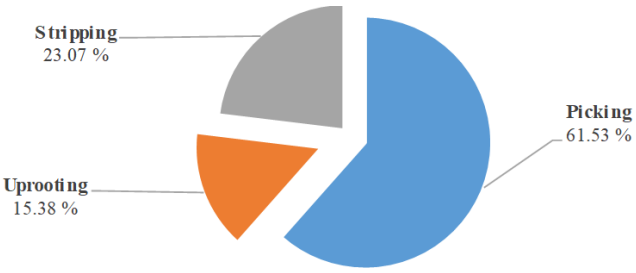


Figure 5. Distribution of the most used state of the plant

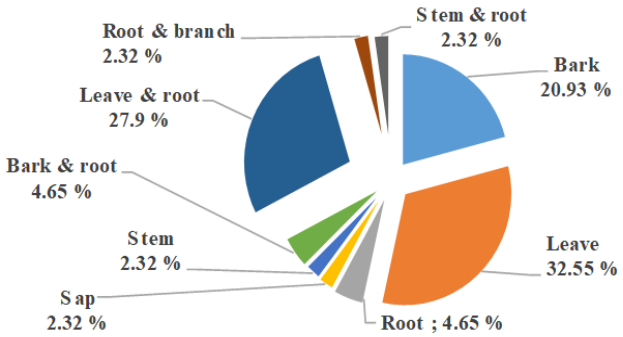


Figure 7. Percentage of plant parts used for medicinal purpose

Table 1. Socio-participants characteristics of the respondents in the study area

Socio-economic variables	Characteristics	Freq.	Percent. (%)
Age classes (years)	30 to 40	90	30.55
	40 to 50	76	25.82
	50 to 60	128	43.63
Total			**100**
Gender	Male	59	20
	Female	235	80
Total			**100**
Residence	Abobo	175	59.52
	Adjamé	46	15.64
	Yopougon	73	24.84
Total			**100**
Socio-cultural group	Indigenous people	38	12.92
	Immigrant people	256	87.08
Total			**100**
Educational level	Illiterate	155	52.63
	Schooled	139	47.37
Total			**100**
Socio-professional activities	Mechanics	59	20.2
	Traders	110	37.6
	Housewives	125	42.2
Total			**100**
Family status	Single	167	56.76
	Married	127	43.24
Total			**100**

Note: *Total exceeded the number sampled due to multiple socio-economic activities calculation is however based on number sampled

Comparison of important species of plants in the study area used by the local people

The majority of the community in the study area relied on wild plants for various purposes such as pharmacopeia, Human and animal food. The Abobo municipality had a high mean specific richness in all three areas of use. Then comes the community of Yopougon and finally that of Adjamé with low average specific richness. The study of the average specific richness of the species used in the different fields indicated a significant difference in the number of species for medicinal and food use (human and animal) in the different municipalities (Table 4). Furthermore, a significant difference in the mean of all category uses mentioned was found between the age groups, with a greater number of medicinal plants mentioned by elderly peoples (above 50 years) than young ones (30-50 years) (Kruskal-Wallis Test; $p<0.05$).

Table 2. List of human foods plant used, part used, types of harvest and their use rates

Human foods plant used	Plant family	Part used	Type of harvest	Use rates (%)
Blighia sapida K.D.Koenig	Sapindaceae	Fruit	Picking	9.25
Calamus deeratus G.Mann & H.Wendl.	Arecaceae	Terminal bud	Stripping	5.36
Chrysophyllum subnudum Baker	Sapotaceae	Fruit	Picking	6.25
Ceiba pentandra Ceiba pentandra	Malvaceae	Young leave	Stripping	11.23
Cola nitida (Vent.) Schott & Endl.	Malvaceae	Seed	Picking	4.12
Elaeis guineensis Jacq.	Arecaceae	Seeds, Terminal bud	Uprooting	5.63
Laccosperma secundiflorum (P.Beauv.) Kuntze	Arecaceae	Terminal bud	Stripping	6.33
Myrianthus arboreus P.Beauv.	Urticaceae	Bud	Picking	15.25
Myrianthus libericus Rendle	Urticaceae	Bud	Picking	14
Napoleonaea vogelii Hook. & Planch.	Lecythidaceae	Fruit	Picking	6.23
Raphia hookeri G.Mann & H.Wendl.	Arecaceae	Terminal bud	Uprooting	3.55
Spondias mombin Jacq.	Anacardiaceae	Fruit	Picking	3
Strombosia pustulata Oliv.	Olacaceae	Fruit	Picking	9.8

Table 3. Medicinal plant species and their uses

Plant name	Mode of use	Medical uses and part used
Albizia adianthifolia (Schumach.) W.Wight	Decoction	Dizziness (bark & leaves)
Albizia zygia (DC.) J.F.Macbr.	Decoction	Dysentery, diarrhea (bark)
Alchornea cordifolia (Schumach. & Thonn.) Müll.Arg.	Decoction	Varicella, malaria (leave, bark), haemostatic (leave & bark), fortifying (leave & bark), dysentery (young leave), fortifying (dry leave)
Alstonia boonei de Wild.	Decoction	Ictery, malaria (bark & leaves)
Annickia polycarpa (DC.) Setten & Maas	Decoction	Malaria (bark & root)
Anchomanes difformis (Blume) Engl.	maceration	Cough, rheumatism (young leave)
Antiaris toxicaria (Pers.) Lesch.	Decoction	Healing (bark)
Baphia nitida G.Lodd.	Decoction	Headache (leave, bark)
Bambusa vulgaris Schrad. ex J.C.Wendl.	Decoction	Typhoid fever (young leave)
Blighia sapida K.D.Koenig	Decoction	Aphrodisiac, curvature (leave, bark), ictery, (leave & bark)
Blighia welwitschii (Hiern) Radlk.	Decoction	Ictery, lepsy (bark)
Buchholzia coriacea Engl.	maceration	Breastfeeding (leave & bark)
Ceiba pentandra (L.) Gaertn.	Decoction	Cough, heartache (leave & bark)
Chromolaena odorata (L.) R.King & H.Rob.	Decoction	Healing, belly pain (leave)
Cola nitida (Vent.) Schott & Endl.	Decoction	Fountain (bark)
Costus afer Ker Gawl.	Decoction	Belly wound (leave)
Elaeis guineensis Jacq.	Decoction	Asthma, rheumatism (root), dental crest, lack appetite (root & branch)
Ficus exasperata Vahl	Decoction	Bone tuberculosis (leave)
Harungana madagascariensis Poir.	Decoction	Malaria (leave), hemorroid (bark)
Microdesmis keayana J.Léonard	Decoction	Gall, aphrodisiac (bark & root), snake bite (leave & roots) migraine (leave)
Myrianthus arboreus P.Beauv.	Decoction	Kidney pain (leave), angina (bark)
Napoleonaea vogelii Hook. & Planch.	Decoction	Rheumatism, curvature, healing (bark)
Newbouldia laevis (P.Beauv.) Seem.	Decoction	Dysentery (bark & leaves)
Palisota hirsuta (Thunb.) K.Schum.	Decoction	Rheumatism (leave)
Paullinia pinnata L.	Decoction	Malaria, vomiting, vertigo (leave), fortifying, cholera, high blood pressure (stem & root)
Phyllanthus muellerianus (Kuntze) Exell	Decoction	Dysentery (leave)
Pycnanthus angolensis (Welw.) Exell	Decoction	Toothache (sap), angina (bark)
Spondias mombin Jacq.	Decoction	Belly pain (leave)
Sterculia tragacantha Lindl.	Decoction	Nerve attack (bark & leaves)
Strombosia pustulata Oliv.	Decoction	Curvature (bark)

Table 4. Comparison of the means effects by category of use (mean ± standard error)

Category of use	Local name			Statistical parameters	
	Adjamé	Abobo	Yopougon	F	P
Pharmacopeia	5.8 ± 1.2^{b}	22.4 ± 2.11^{a}	10 ± 2.28^{b}	k=3.815	P=0.04*****
Human food	2.4 ± 0.5^{b}	7.8 ± 1.15^{a}	2.6 ± 0.92^{b}	k=1.031	P=0.03*****
Animal food	1 ± 0.31^{b}	4.8 ± 0.58^{a}	2 ± 0.44^{b}	k=4.126	P=0.02*****

Note: *Significant overall means effects, *p<0.05*. For category of use, means with different letters are significantly different based on Tukey's HSD test

Discussion

A total of 36 plant species belonging to 34 genera distributed among 28 families are used by the riparian population of BNP. This value of 36 species remains lower than that of Adomou et al. (2017), which identified 94 plant species belonging to 89 genera distributed among 47 families in the Bahazoun forest in South Benin. The difference in the number of species could be explained by sampling effort. However, again, those results are explained by the retention of information by the resource persons on the virtues of species and knowledge (Adomou et al. 2012). This situation may cause a reduction in the number of species.

According to the socio-demographic information, most of the respondents were female. These results can be explained by the fact that women have in-depth knowledge of medicinal species and their different therapeutic uses compared to men and that women were responsible for the first aid of their grandchildren. This result agrees with the findings reported by Borokini et al. (2013), who reported that 58.1% of the respondents in an ethnobiological study of traditional medicines used for women's health in Oyo state, Nigeria were female. These results were in line with the results obtained elsewhere by other ethnobotanical studies conducted in the different regions of Morocco by Benlamdini et al. (2014). Women, in general, have great know-how in the field of traditional herbal medicine and also have a great responsibility as mothers and homemakers. They give first aid to care, especially within their families. Also, women are aware of the responsibility they own in their families (Chohra and Ferchichi 2019).

The result also revealed that most of the respondents were between 40 to 50 years of age, which showed that people of old age were the main custodians of traditional

knowledge compared to other age groups. The oldest people did the most reliable information for medicinal plants in traditional medicine because they have good ancestral knowledge that is part of their oral tradition. It was noticeable that there was an information lack regarding young people that tend not to believe in this traditional medicine (Chohra and Ferchichi 2019). These results were due, on the one hand, to the fact that older people are familiar with traditional medicine compared to other age groups, and on the other hand, to the mistrust of young people under 20 years old who did not believe much in this traditional medicine (Jaadan et al. 2020).

In our study area, a large proportion of plant users were illiterate. Furthermore, most of the respondents had no formal education, and these findings were attributed to the fact that women, who were the majority of the respondents, were not enrolled in women's schools relatively high percentage correlated with the educational level of the local population of BNP. Nevertheless, people with primary school education had an average percentage of medicinal plant use, while secondary and university education used medicinal plants sparingly in their therapeutic treatment. These results were in line with other studies by Kpodar et al. (2015).

According to family situations of all traditional medicines; human and animal food users by the riparian population of BNP, the single proportion was more than married. These results could be explained by the fact that single people try to reduce their financial burdens and the very high costs of pharmaceutical products as much as possible. Moreover, the park is delimited by precarious neighborhoods where low-income populations live. This explains the high proportion of single people living near the park.

The socio-professional activities noted around the park are mechanics, traders and homemakers. These people have the habit of entering the park for samples of natural resources for their daily needs.

Analysis of the collected information showed that the most consumed species were *M. arboreus* and *M. libericus*. It also showed that the consumption of a species depends on its availability, which explains the frequency of low or high citations observed in some species. However, the species of *M. arboreus* and *M. libericus* had the highest citation frequencies. This finding was already mentioned by Dossou et al. (2012) during the ethnobotanical study of woody forest resources in the Agonvè marshy forest and related land in Benin. Indeed, the importance attached to a species does not depend on its availability but on its ability to meet the needs of populations in the different categories of uses (Allabi et al. 2011). Also, this low rate could be explained by the fact that this survey occurred in urban areas where people use different food supply sites.

The inventory of feed species and their percentage citation frequencies were: *P. maximum*, *F. exasperata* and *Elaeis guineensis* Jacq. whose mode of use is grazing. The low utilization of plant species may explain this low level of herbal species richness because the present survey was conducted in urban settings where several health centers use disease populations for appropriate care.

In our results (Table 7), the use rate of its different parts shows that the leaves are the most used and bark occupies second place. The obtained results are in good accordance with the literature, Az-Zahra et al. (2021) affirmed that leaves are the most used in the recipes of traditional medicine. Also, leaves are plants' main photosynthetic organs, and photosynthates are translocated to other parts, such as the root, stem, fruit, and seed. These can act as toxins to protect from predators; some are of medicinal value to humans (Amsalu et al. 2018).

The population has a greater knowledge of medicinal plant species, reflected in the common use in the traditional pharmacopeia of *M. keayana*, *S. pustulata*, *A. cordifolia* and *B. vulgaris*. The most commonly used organs are barking, leaves and roots. Treated diseases are most often hemorrhoid and other supernatural diseases. For most of these species, roots that are highly sensitive organs were used in the traditional pharmacopeia, particularly to treat hemorrhoid seizures. These diseases are very common in rural areas, which justifies the excessive removal of the roots of these species.

There are 30 plant species used in the traditional pharmacopeia for a wide spectrum of therapeutic action. However, this number remains lower than Ilyass et al. (2021), with 283 species in Morocco. This inferiority in the number of species could be due to several pathologies identified by these authors since the vast majority of plant species are specific to different diseases.

Of the diseases frequently treated in the study area, most of the spectrum was provided by malaria. In line with Black et al. (2010), diseases such as diarrhea and malaria are the major causes of child mortality in Africa. The abundance of a chemical compound in the leaves that are the synthesis seat of the secondary metabolites of the plant gives them broad therapeutic possibilities for many diseases, thus justifying the frequent use of the leaves (Kumar and Lalramnghinglova 2011). These results can be explained by the ease of harvesting the leaves and the fact that the leaves are the site of photosynthesis and storage of secondary metabolites responsible for the biological properties of the plant (Boughrara and Belgacem 2016).

In terms of the mode of use, the decoction was the most used mode. These results showed that the population adopts the decoction method and finds it adequate to warm the body and disinfect the plant (Boughrara and Legseir 2016). Corroborating the work of Barkaoui et al. (2014), the decoction allows for a collection of the most active ingredients and attains or cancels the toxic effect of certain recipes. Other studies that obtained the same results were done by Salhi et al. (2010). Similarly, several studies have shown that, among many forest plant species used by riparian forest populations, only medicinal use is most important. The results obtained in this study corroborate those of Kouakou et al. (2017) in the Haut-Sassandra Classified Forest. In general, plant species remain one of the main sources of food, medicines for rural and urban populations in tropical Africa (Hama et al. 2019).

However, patterns of use in the study area pose a threat to most species. For example, some three species are already considered rare in the study area due to harvest and

mismanagement of stands. These species include *A. polycarpa*, *N. leavis* and *B. coriacea*. The result is a gradual degradation of the environment that results in a depletion of woody species. Similarly, Traoré et al. (2011) point out that species affected by excessive organ harvesting can no longer perform their physiological functions to the best of their potential, which necessarily influences the production of fruits and seeds, which ensure the survival of the species.

High medicinal plant usage is putting significant pressure on these plant resources and their habitat. These different anthropogenic pressures on stands have a significant negative impact, inducing structural change and increasing their degradation. According to the population surveyed, barking, illegal cutting, uprooting, grinding and gathering remain the main factors that threaten several plant species. The different practices of the species revealed are grouped into; animal food, human food, and pharmacopeia.

However, the survey demonstrates that most of these present natural resources are at risk of disappearance. Therefore, the plant species should be given particular attention to rationalizing their uses.

ACKNOWLEDGEMENTS

We thank Colonel Fousseni COULIBALY for allowing us to conduct our fieldwork on the BNP, Abidjan, Ivory Coast. Our thanks also go to Mrs. Hortense Nabote and Julien Kouame for their honest cooperation in guiding the investigations. Finally, the authors of this article would like to translate their recognition to the Swiss Center for Scientific Research in Ivory Coast, which contributed to the confirmation of the inventoried plant species.

REFERENCES

Adomou AC, Dassou HG, Houenon GHA, Alladaye A, Yedomonhan H. 2017. Comprendre les besoins en ressources végétales des populations riveraines pour une gestion durable de la forêt Bahazoun au Sud-Bénin (Afrique de l'Ouest). Intl J Biol Chem Sci 11 (5): 2040-2057. DOI: 10.4314/ijbcs.v11i5.9. [French]

Adomou AC, Yedomonhan H, Djossa B, Legba SI, Oumorou M, Akoegninou A. 2012. Étude ethnobotanique des plantes médicinales vendues dans le marché d'Abomey-Calavi au Bénin. Intl J Biol Chem Sci 6 (2): 745-772. DOI: 10.4314/ijbcs.v6i2.18. [French]

Adou LMD, Gonezieti Bi BHJ, Zirihi GN, 2018. Enquête Ethnobotanique et Utilisations des Ptéridophytes du Parc National du Banco, District d'Abidjan (Côte d'Ivoire). J Anim Plant Sci 38 (2): 6206-6216. DOI: 10.35759/janmplsci.v49-1.3. [French]

Agbo IR, Missihoun AA, Vihotogbe R, Assogbadjo EA, Ahaahanzo C, Agbangla C. 2017. Impacts des usages traditionnels sur la vulnérabilité de *Detarium microcarpum* Guill. & Perr. (Caesalpiniaceae) dans le district phytogéographique Zou au Bénin (en Afrique de l'Ouest). Intl J Biol Chem Sci 11 (2): 730 - 742. DOI: 10.4314/ijbcs.v11i2.16. [French]

Agúndez D, Nouhoheflin T, Coulibaly O, Soliño M, Alía R. 2020. Local preferences for shea nut and butter production in Northern Benin: Preliminary results. Forests 11 (12): 1-14. DOI: 10.3390/f11010013.

Allabi AC, Busiac K, Ekanmiana V, Bakiono F. 2011. The use of medicinal plants in self-care in the Agonlin region of Benin. J Ethnopharmacol 133: 234-243. DOI: 10.1016/j.jep.2010.09.028.

Amsalu N, Bezie Y, Fentahun M, Alemayehu A, Amsalu G. 2018. Use and conservation of medicinal plants by indigenous people of Gozamin Wereda, East Gojjam Zone of Amhara Region, Ethiopia: An ethnobotanical approach. Evid-Based Complement Altern Med 2018: 2973513. DOI: 10.1155/2018/2973513.

Aragaw TJ, Afework DT, Getahun KA. 2020. Assessment of knowledge, attitude, and utilization of traditional medicine among the communities of Debre Tabor Town, Amhara Regional State, North Central Ethiopia: A cross-sectional study. Evid-Based Complement Altern Med 2020: 6565131. DOI: 10.1155/ 2020/6565131.

Az-Zahra FR, Sari NLW, Saputry R, Nugroho GD, Sunarto, Pribadi T, Setyawan AD. 2021. Review: Traditional knowledge of the Dayak Tribe (Borneo) in the use of medicinal plants. Biodiversitas 22: 4633-4647. DOI: 10.13057/biodiv/d221057.

Barkaoui M, Katiri A, Boubaker H, Msanda F. 2014. Ethnobotanical survey of medicinal plants used in the traditional treatment of diabetes in Chtouka Ait Baha and Tiznit (Western Anti-Atlas), Morocco. J Ethnopharmacol 198: 338-350. DOI: 10.1016/j.jep.2017.01.023.

Benlamdini N, Elhafian M, Rochdi A, Zidane. 2014. Étude floristique et ethnobotanique de la flore médicinale du Haut Atlas oriental (Haute Moulouya). J Appl Biosci 78: 67-71. DOI: 10.4314/jab.v78i1.17. [French]

Black RE, Cousens S, Johnson HL, Lawn JE, Rudan I, Bassani DG, Jha P, Campbell H, Walker CF, Cibulskis R, Eisele T, Liu L, Mathers C. 2010. Global, Regional, and national causes of child mortality in 2008: A systematic analysis. The Lancet 375 (9730): 1969-1987. DOI: 10.1016/S0140-6736(10)60549-1.

Borokini TI, Ighere DA, Clement M, Ajiboye T O, Alowonle AA. 2013. Ethnobiological surved of traditional medecine practice for women's health in Oyo State. J Med Plant Stud 1 (5): 17-29. DOI: 10.22271/plants.

Boughrara B, Belgacem L. 2016. Ethnobotanical study close to the population of the extreme north east of Algeria: The municipalities of El Kala National Park (EKNP). Ind Crops Prod 88: 2-7. DOI: 10.1016/j.indcrop.2016.03.009.

Chohra D, Ferchichi L. 2019. Ethnobotanical study of Belezma National Park (BNP) plants in Batna: East of Algeria. ASN 6 (2): 40-54. DOI: 10.2478/asn-2019-0017.

De Sy V, Herold M, Achard F, Avitabile V, Baccini A, Carter S, Clevers JGPW, Lindquist E, Pereira M, Verchot L. 2019. Tropical deforestation drivers and associated carbon emission factors derived from remote sensing data. Environ Res Lett 14 (2019): 1-14. DOI: 10.1088/1748-9326/ab3dc6.

Dogara A, Labaran I, Hamad SW, Lema AA, Jakada BH. 2021. Traditional medicinal plants used for the treatment of cancer in Mubi, Adamawa State, Nigeria. Al Qadisiyah J Pure Sci 26 (4): 258-268. DOI: 10.29350/qjps.2021.26.4.1423.

Dossou ME, Houessou GL, Lougbegnon OT, Tente AHB, Codjia JTC. 2012. Etude ethnobotanique des ressources forestières ligneuses de la forêt marécageuse d'Agonvè et terroirs connexes au Bénin. Tropicultura 30 (1): 41-48. DOI: 10.25518/2295-8010. [French]

Dro B, Soro D, Koné M, Bakayoko A, Kamanzi K. 2013. Evaluation de l'abondance de plantes médicinales utilisées en médecine traditionnelle dans le Nord de la Côte d'Ivoire. J Anim Plant Sci 17 (3): 2631-2646. DOI: 10.35759/janmplsci.v49-1.3. [French]

Gaoue OG, Coe MA, Bond M, Hart G, Seyler BC, McMillen H. 2017. Theories and major hypotheses in ethnobotany. Econ Bot 71 (30): 269-287. DOI: 10.1007/s12231-017-9389-8.

Guissou KML, Kristiansen T, Lykke AM. 2015. Local perceptions of food plants in Eastern Burkina Faso. Ethnobot Res Appl 14: 199-209. DOI: 10.32859/era.21.49.199-209.

Hama O, Tinni I, Barage M. 2019. Contribution des produits forestiers non ligneux à la sécurité alimentaire des ménages dans la commune rurale de Tamou, au Sud-ouest du Niger (Afrique de l'Ouest). Intl J Adv Res 7 (10) : 210-227. DOI: 10.21474/ijar01/9824. [French]

Ilyass AM, Loubna K, Noureddine B, Mostafa E. 2021. Ethnobotanical profile of medicinal plants used by people of North-eastern Morocco: Cross-cultural and historical approach (Part I). Ethnobot Res Appl 21 (34): 1-45. DOI: 10.32859/era.21.34.1-45.

Jaadan H, Akodad M, Moumen A, Baghour M, Skalli A, Ezrari S, Belmalha S. 2020. Ethnobotanical survey of medicinal plants growing in the region of "Oulad Daoud Zkhanine" (Nador Province), in Northeastern Morocco. Ethnobot Res Appl 19: 1-12. DOI: 10.32859/era.19.39.1-12.

Kouakou KA, Barima YSS, Zanh GG, Traoré K, Bogaert J. 2017. Inventaire et disponibilité des produits forestiers non ligneux utilisés par les populations riveraines de la Forêt Classée du Haut-Sassandra

après la période de conflits armés en Côte d'Ivoire. Tropicultura 35 (2): 121-136. DOI: 10.25518/2295-8010.1219. [French]

Kouakou YB, Malan DF, Kouassi KG, Diop AL, Bakayoko A. 2020. Disponibilité de quelques plantes alimentaires spontanées utilisées par les populations Koulango et Lobi de la périphérie Est du Parc National de la Comoé, Côte d'Ivoire. Eur Sci J 16 : 295-320. DOI: 10.19044/esj.2020.v16n9p295. [French]

Kpodar M, Lawson-evi P, Bakoma B, Eklugadegbeku K, Agbonon A, Aklikokou K, Gbeassor M. 2015. Ethnopharmacological survey of plants used in the treatment of diabetes mellitus in south of Togo (Maritime Region). J Herb Med 5 (3): 147-152. DOI: 10.1016/j.hermed.2015.06.002.

Kumar P, Lalramnghinglova H. 2011. India with special reference to an Indo-Burma hotspot region. Ethnobot Res Appl 9: 379-420. DOI: 10.17348/era.9.0.379-420.

Mahmoud AD, Labaran I, Yunusa A. 2020. Ethnobotany of medicinal plants with antimalarial potential in Northern Nigeria. Ethnobot Res Appl 19: 1-8. DOI: 10.32859/era.23.7.1-8.

Ndiaye I, Camara B, Ngom D, Sarr O. 2017. Diversité spécifique et usages ethnobotaniques des ligneux suivant un gradient pluviométrique Nord-Sud dans le bassin arachidier sénégalais. J Appl Biosci 113: 11123-11137. DOI: 10.4314/jab.v113i1.2. [French]

Ouédraogo I, Sambaré O, Savadogo S, Thiombiano A. 2020. Perceptions locales des services écosystémiques des aires protégées à l'Est du Burkina Faso. Ethnobot Res Appl 20 (13): 1-18. DOI: 10.32859/era.20.13.1-18. [French]

Ouédraogo P, Bationo B A, Sanou J, Traoré S, Barry S, Dayamba SD, Bayala J, Ouédraogo M, Soeters S, Thiombiano A. 2017. Uses and vulnerability of ligneous species exploited by local population of northern Burkina Faso in their adaptation strategies to changing environments. Agric Food Sec 6 (15): 1-16. DOI: 10.1186/s40066-017-0090z.

Salhi S, Fadli M, Zidane L, Douira A**.** 2010. Etudes floristique et ethnobotanique des plantes médicinales de la ville de Kénitra (Maroc). Lazaroa 31: 133-146. DOI: 10.5209/rev_laza.2010.v31.9. [French]

Shaheen H, Qaseem MF, Amjad MS, Bruschi P. 2017. Exploration of ethno-medicinal knowledge among rural communities of Pearl Valley; Rawalakot, District Poonch Azad Jammu and Kashmir. PloS One 12 (9): e0183956. DOI: 10.1371/journal.pone.0183956.

Teka A, Asfaw Z, Demissew S, Van Damme P. 2020. Traditional medicinal plant use of indigenous communities in Gurage Zone, Ethiopia. Ethnobot Res Appl 19 : 1-31. DOI: 10.32859/era.19.41.

Tiébre M-S, Kouamé D, Vroh TB, N'Da DK, Yao Y-C A. 2014. Stratégies et potentiel d'invasion des massifs forestiers par *Hopea odorata* Roxb. (Dipterocarpaceae): Cas du Parc National du Banco en Côte d'Ivoire. Intl J Biol Chem Sci 8 (2): 666-679. DOI: 10.4314/ijbcs.v8i2.23. [French]

Traoré L, Ouédraogo I, Ouédraogo A, Thiombiano A. 2011. Perceptions, usages et vulnérabilité des ressources végétales ligneuses dans le Sud-Ouest du Burkina Faso, Intl J Biol Chem Sci 5 (1): 258-278. DOI: 10.4314/ijbcs.v5i1.68103. [French]

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 5, Number 2, November 2022 E-ISSN: 2580-4510
Pages: 130-137 DOI: 10.13057/asianjethnobiol/y050206

Ethnobotanical survey and conservation of the indigenous plants used for traditional orthopedic care practices in Bayelsa Central Senatorial District, Nigeria

HINMIKAIYE S. OLATOKUNBO[1], MARY K. OLANIPEKUN[2,♥], OBEMBE O. MICHAEL[2]
[1]Federal University Otuoke. Bayelsa State, Nigeria
[2]Department of Plant Science and Biotechnology, Ekiti State University. Ekiti State, Nigeria. Tel. +234-8037252776,
♥email: mary.olanipekun@eksu.edu.ng

Manuscript received: 6 April 2022. Revision accepted: 20 November 2022.

Abstract. *Olatokunbo HS, Olanipekun MK, Michael OO. 2022. Ethnobotanical survey and conservation of the indigenous plants used for traditional orthopedic care practices in Bayelsa Central Senatorial District, Nigeria. Asian J Ethnobiol 5: 130-137.* The practices of the trado-orthopedic system of healing in all forms among indigenous healers are extensively linked to plant resources. We investigated the plant species exploited among folks involved in traditional orthopedic care services in Bayelsa Central Senatorial District, Nigeria. The district was delineated into three Local Government Areas (LGAs). Information on the plant species used for traditional orthopedic services was fetched by an open-ended conversation with 150 respondents across 15 communities in the LGAs. The respondents are mostly women, 117 (78%), while 33 (22%) are men. The adults 60 (52.67%) years and above showed more interest in using traditional medicine than the younger ones. The young people considered traditional medicine superstitious and used by uneducated or poor people. Thirty-nine (39) plant species in thirty (30) different families were accessed as species used for bone healing in the area. Thirty-two (82%) species of the plants were found on the scale of abundance, while seven of the species (18%) accessed were rare in occurrence. The plants were used as food, timber, and medicine; the highest citations occurred in Malvaceae and Amaranthaceae families, with three species each. Different sections of the plants were exploited for treatment options ranging from bone hardening to pain reliever, fester prevention and swelling, to pushing dislocated bones back in position. Physical examinations and oral interviews are major tools among TOCPs in the diagnostic test to ascertain the level of casualty such as deformity, the inability of the limb to act, and shortened limb, among others. Also, the extraction pattern, which was either predatory or annihilative, was noted. Given the preceding, plants for sustainable use of the species were proposed. Moreover, we recommended that further research into the efficacy and safety use of the species in treating fracture and bone-related ailments are taken on.

Keywords: Abundance, Bayelsa Central Senatorial District, bone healing, conservation, medicinal plants, traditional orthopedic care

INTRODUCTION

The roles of plant resources in human society are manifold; aside from their basic uses for food and shelter, they are also being exploited as a suitable material for medicine, especially in rural areas (Tilahun and Moa 2018; Gaddy 2020; Ihinmikaye and Akinjagunla 2020; Az-Zahra et al. 2021). Ethnomedicine, a branch of botanical research that deals with the relationships between indigenous people and the plant community exploited in folk medicine to maintain health, prevent and treats physical and mental sicknesses based on theories, folk beliefs, and experiences (Gureje et al. 2018; Suchita 2019). There is medicine in plants. Plants show healing effects through different mechanisms like boosting the immune system, decreasing bacterial count, modulation wound and fracture healing, remodeling fibrin-rich granulation tissue, improving collagen deposition, increasing fibroblasts and fibrocytes, etc. (Sheen and Garla 2019). The economic benefits of the use and the development of indigenous medicines from medicinal plants for the treatment of various diseases, such as back pains, chicken pox, infections, gonorrhea, syphilis, stroke, diarrhea, wound healing, and skin diseases, among others, were reported to be among the illnesses that traditional healers can treat (Tugume et al. 2016; Aziz et al. 2017; Tewelde et al. 2017; Kidane et al. 2018).

The potency, relevance, and use of herbal medicine result from the inherent bioactive ingredients present in medicinal plants when used as herbal remedies (Adedeji et al. 2018). Therefore, the practice of traditional medicine, especially in remote areas, plays a notable role in the prevention and healing of people's health, as reported by Liu et al. (2009), Ahmad et al. (2014), Tugume et al. (2016), Tewelde et al. (2017), Aziz et al. (2017), and Kidane et al. (2018). It was estimated that 3.5 billion people in the developing world depend on medicinal plants as part of their primary health care (Balick and Cox 1996; Ahmad et al. 2014; Olanipekun et al. 2020). That was corroborated by the reports of WHO that 80% of the world's inhabitants, especially in developing countries, depend on traditional medicine for their primary healthcare needs (Bannerman et al. 1983; Aziz et al. 2017). Unfortunately, synthetic drugs and access to high-quality orthopedic care in the hospital are not well available in rural areas, especially in the study areas. Therefore, treating Musculoskeletal and bone fractures injuries is usually done using herbal medicine with plants. That could also be because of the high cost of modern medicine compared to

indigenous herbal medicines, wide socio-cultural acceptance of traditional medicine, and the belief that natural products pose less or no risk are the various advantages herbal medicine has over orthodox medicine. In orthopedics management, bone healing using plants and their extract and poultice together with a splint without a cast is widely practiced in traditional medicine. In Nigeria, the diverse floristic compositions of plant forms, which include trees, shrubs, herbs, and other non-timber forest resources, have contributed greatly to the widespread use of Nigerian plants as medicine (Sonibare and Gbile 2008; El-Ghani 2016; Erinoso and Aworinde 2018; Lawal et al. 2020; Mukaila et al. 2021; Ajao et al. 2022). The use of medicinal plants is well-known among the indigenous peoples in Bayelsa, the Eastern part of Nigeria. Also, the acceptance and use of herbal medicine are increasing globally because of its effectiveness and availability of plant materials (Zhu and Woerdenbag 1995; Huai and Pei 2002; Brandão et al. 2006). Bone healing or fracture healing is a proliferative, physiological process in which the body facilitates the repair of a bone fracture. It involves complex processes of cell and tissue proliferation and differentiation. The treatment consists of pushing dislocated bones back in place via relocation with or without anesthesia, stabilizing their position, and then waiting for the bone's natural healing process.

However, bone healing using plants and their extract and poultice together with a splint without a cast is widely practiced in traditional medicine. The traditional bone healing process focuses on diagnosing, preventing, and correcting disorders and deformation related to the musculoskeletal system (Esrafilian et al. 2013). Also, traditional medicine practitioners specialize in using plant materials to treat bone and fracture repair (Alam et al. 2016), employing different tactics such as massage, traction, splint, etc., using the plant as the main raw material in manipulating and setting fractures. Such understanding came through a series of long observations and trials from one generation to another, and the knowledge is transmitted orally to posterity or apprenticed (Onuminya 2004; Dada et al. 2011). Also, the increased preference for herbal medicine has consequently propelled the search for pharmaceutical remedies against different ailments from plants. Unfortunately, many medicinal plants are collected from the wild, which has negatively affected the availability of plant resources due to unsustainable exploitation rates and the health of many people who cannot afford orthodox medicine.

Nevertheless, various studies have identified and documented medicinal plants of medicinal importance. Interestingly, the rich history of African cultures and their innovative utilization of plants as a source of remedies have been passed down through generations mainly by oral tradition (Olanipekun et al. 2020). However, unfortunately, this knowledge is gradually lost due to inadequate written documentation, overharvesting of medicinal plants from their natural habitat, and conversion of forest reserves for building or construction purposes. That poses a major threat to traditional medicine as the custodians hold the information secretly and die before passing on information to the younger generations (Su et al. 2011).

It was noted that studies on plants used by the people of Bayelsa State for the traditional bone healing process are rare; in fact, a literature search shows that a dearth of studies on plant species use in trado-orthopedic care among other ethnic groups in Nigeria abounds. Therefore, substantial documentation remains important to mitigate the potential loss of valuable indigenous knowledge associated with plant resources used in trado-orthopedic care among local communities. Furthermore, the potential of medicinal plants is still far from being extensively explored locally and nationally as well as internationally. Thus, this study aims at generating an inventory of plants with the medicinal value among selected local communities in Bayelsa State.

MATERIALS AND METHODS

Description of study area

Bayelsa Central Senatorial District (BSCD), Nigeria, is one of the three districts that constitute Bayelsa State. The senatorial district comprises three Local Government Areas (LGA): Yenegoa, Southern Ijaw, and Kolokuma/Opokuma, which lies between latitudes 5°70' and 6°43' N and longitudes 4°60' and 4°81' E, with a landmass about 3,004 km^2. The climate is tropical, with mean monthly temperature ranging from 25°C to 31°C. Ethnic Ijaw groups such as Kolokuma, Ekpetiama, Igbriran, Epie/ Atissa, and Biseni are the main inhabitants of the area. Farming and fishing are the predominant trades, though many engage in businesses related to forest resources.

Socio-demographic characteristics of the respondents

The reference population was all persons over 30 years of age born and living in various locations in the state as shown in Figure 1. An open-ended, semi-structured questionnaire was used to carry out this research. The questionnaire was used to assess 150 people from March 2020 to March 2021. The various questions were based on the population's socio-demographic characteristics, age, sex, profession, education status, and family situation. Also, information on the medicinal plants of importance, such as species name, part of the plants identified, methods and mode of preparation, and information on conservation measures, were assessed and documented.

Sample collection and identification

The study was conducted between March 2020 and March 2021. Fifteen communities were selected for the study: Korokorosei, Ekeni, Ayama, Otuan, and Odewari, in Southern-Ijaw LGA; Beseni, Zarama, Polaku, Igeibiri, Gbaran, in Yenagoa LGA; and Kaiama, Odi, Ogboloma, Sampou, Opokuma in Kolokuma/ Opokuma LGA. A total of 150 respondents (50 from each LGA) comprised of traditional bone healers and members of the communities who had maintained domicile for less than 15 years and with knowledge of plants used for fracture treatment and bone-related disorders were selected for the study. The bone healers selected were well-known in the community based on skill and years of experience.

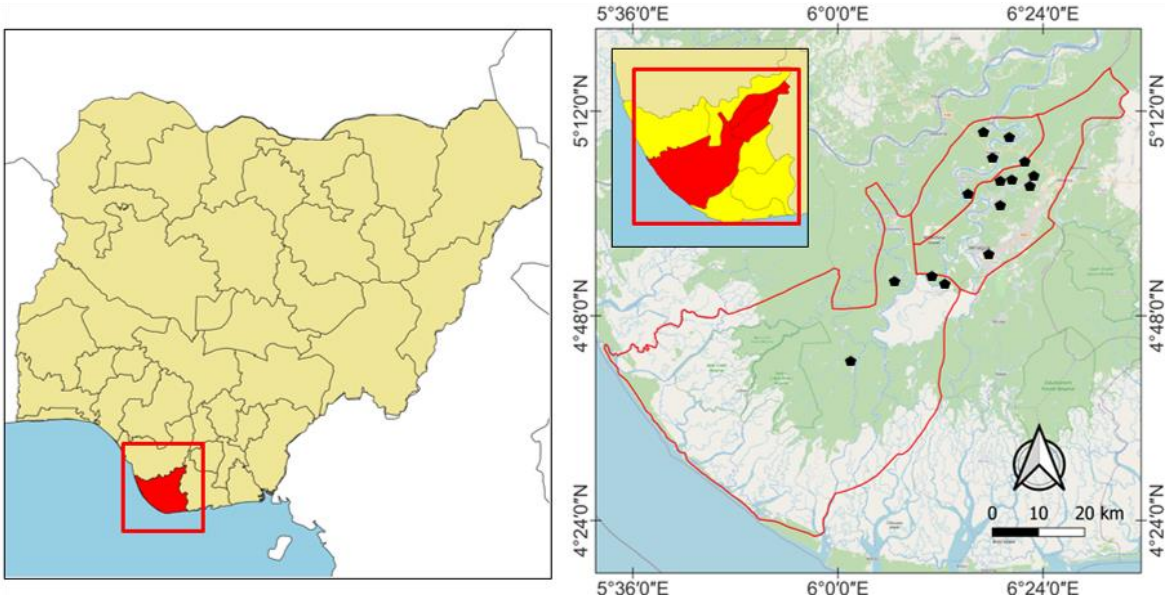


Figure 1. Map of Bayelsa State in Nigeria showing the study area

An open-ended conversation, structured questionnaire guide, and direct field observation allow each respondent to express personal viewpoints freely without being interrupted or contradicted by others (Martin 1995). The interview provided various information on the conditions associated with bone fractures and management. Similarly, plant species that could be used as herbal medicine to treat fractures were documented. Also, the parts of the plants, the habit, the habitat, the methods of preparation, the mode of administration, and the abundance status of the plants were recorded. It was also noted that the plants that could be sighted physically between thirty to sixty minutes were documented as common plants, while those that could be seen within sixty minutes to several hours were regarded as scarce, rare, and endangered plant species, respectively (Ihinmikaiye et al. 2020). Voucher specimens of the plants were prepared and deposited at the Herbarium unit of the Department of Plant Science and Biotechnology, Bayelsa State University. All the data collected were encoded in the Microsoft Excel spreadsheet and processed using Statistical Package for Social Sciences (SPSS). Descriptive Statistical analysis (percentages) was used to summarize the data.

Intellectual property agreement statement

Before the interviews, a two-time visit was made to the study area where the Kings, the traditional rulers, and elders were duly informed about the objectives of the research work with a verbal agreement that the information gathered during the research shall be protected and that the research shall not be used for commercial purposes. Still, to enlighten the students and document medicinal plants used for the management of bone fractures in order to protect our heritage from eroded, thus, the interview was granted.

RESULTS AND DISCUSSION

The socio-demographic characteristics of the indigenous people using herbal medicine to manage fractures and the various bones related conditions in the study area reveal that mature and older adults were experienced in using herbal medicine (52.67%) (Table 1). The distribution of knowledge about the use of medicinal plants varies considerably between men and women. While women (78%) used herbal remedies to treat fractures, only (22%) of men used herbal remedies. It was obvious that women knew better about using plants as an alternative therapy than men. This result could be explained by the fact that in the study area, women are in charge of managing the health of the household members, using knowledge acquired from their parents. That was following the report of Deressa and Ali (2009) in the south-central district of Ethiopia that women have a higher general knowledge of managing and treating symptoms associated with health challenges than men. This result is also following the work of Chohra and Ferchichi (2019) and the north African scale by Mehdioui and Kahouadji (2007), who noted that the household management of caring for household members with the prudent spending of the family money and budget is mainly assigned to women to reduce the costs induced by the doctor and on the drug. The respondents of age groups of 60 years and above has the largest representation of 38.22%, while ages between (50-59), (40-49), (30-39) and (20-29) have a percentage of 22.54%, 17.66%, 13.45%, and 8.13% respectively. The older people showed more interest in their demonstration of how to collect, process, administer and prescribe medicinal plants with great belief in the efficacy of herbal remedies than the young generation, which showed low participation in all aspects. That corroborates the work of Abera (2014) on medicinal plants used in traditional medicine by the

Oromo people, Ghimbi District, South-West Ethiopia, in which there was a decreasing positive attitude towards the use of medicinal plants by the younger generation.

The young generation considered traditional medicine superstitious and used by poor and uneducated people. In addition, most of the older adults kept their knowledge secret from the young people to generate income and obtain respect from their community; thus, indigenous knowledge declined. It was also noted that 63.87% of plant users discovered their experiences through trial and error, and those of ancestors in the use of medicinal plants as remedies, 19.28% solicit herbalists. In comparison, 16.85% consult books and radio/television programs specializing in herbal medicine. Also, it was asserted by Teshome (2005) and Abera (2014) that the absence of formal education in traditional knowledge in developing nations is another factor in the decline of indigenous knowledge. On the contrary, medicinal plant use decreased as plant users' education level increased. Health professionals in developed nations intensively search for medicinal plants to combat old, emerging, and re-emerging diseases. Still, their African counterparts greatly underestimate traditional medicine's contribution to health care systems., which may result in the loss of rich and useful traditional knowledge accumulated over many generations.

Thirty-nine (39) plant species belonging to thirty different families were identified as being used for fractures and bone healing processes in the study area (Table 2). Vernacular/Ijaw names of the species identified are presented in the Table. The highest number of plant citations occurred in families Malvaceae and Amaranthaceae, with three species each, while many of the remaining plants were found belonging to one family each. Eighty-two percent (82%) species of the identified plants were found on the abundance scale, while eighteen percent of the species (18%) accessed were rare in abundance. The plants were probably for their primary uses, ranging from food to timber and medicine (Table 2).

Bayelsa Central Senatorial District is rich in biocultural diversity, and ethnomedicinal practices are well appreciated. Most interviewees acknowledged that experience in bone treatments was acquired through knowledge transfer (from one generation to the next) via traditional verbal means and by apprenticeship for substantiating (Vinayak et al. 2012). The Trado-Orthopedic Care Providers (TOCPs) usually administered to treat all kinds of bone fractures and dislocations; meanwhile, different practices such as massage, traction, and splint with sticks were employed in the treatment phases corroborating (Alam et al. 2016). However, complicated cases are referred to superiors (within the study area) whose skills and knowledge sometimes find relevance in conventional healthcare centers in Bayelsa State and beyond, as they are sometimes invited for such jobs. Physical examination and oral interviews are major tools among TOCPs in diagnostic tests to ascertain the level of casualties such as deformity, the inability of the limb to act, shortened limb, gaps in between the bone section affected, severe pain and swelling thus, substantiating (Onuminya 2004), yet in exceptional cases; ritual is performed, and everything engaged were shrouded in secrecy.

Table 1. Demographic profile of the respondents in the study area

Indicator	Description	Total	Frequency (%)
Age	30-39	18	12
	40-49	22	14.67
	50-59	31	20.67
	>60	79	52.67
Gender	Female	117	78
	Male	33	22
Education	Illiterate	71.34	47.56
	Primary	30.04	20.02
	Secondary	28.85	19.23
	University	19.77	13.18

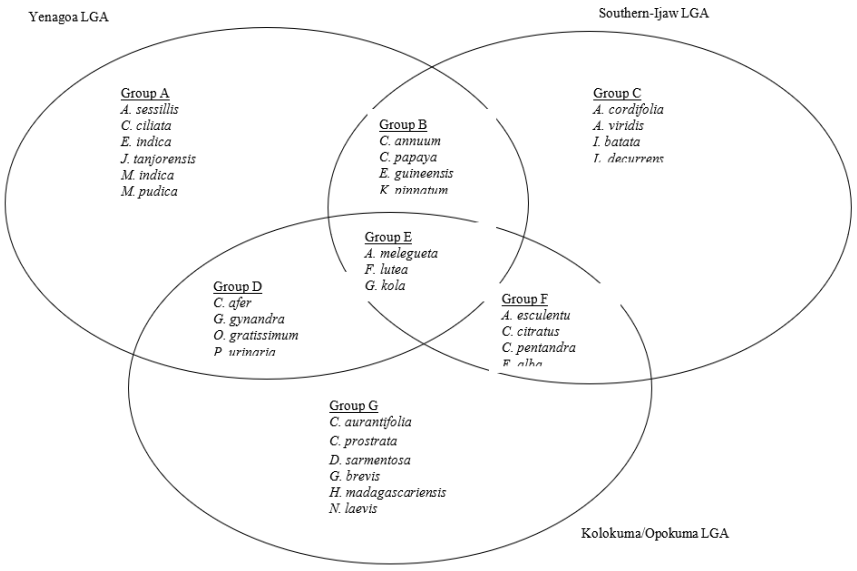


Figure 2. Venn diagram showing similarities in the use of the plant species for trado-orthopedic treatment

Diverse sections of the plants are employed in trado-orthopedic services either singly or in a combination of two and above during preparation and treatment. Each respondent mentioned no fewer than five species as plants for orthopedic care, which follows the reports of Upadhya et al. (2012), Hong et al. (2015), and Vibhi (2017) that citations of medicinal plants that are more than two indicate a good knowledge of informant, biodynamic compounds of therapeutic value and synergistic effects of such medicinal plants and poultice with a splint and without a cast that is widely practiced with positive results in traditional medicine. Leaves were a notable ingredient in the treatment options (Table 2). The exploitation of leaves is better and not annihilative to the plants' survival than stem bark and the roots of plants. Leaves regenerate and re-grow quickly against other parts of plants, which can lead to the death of the plant. Most of the plant species applied in the healing processes grow in the wild, and the proportion cultivated was relatively low, being meant for uses other than orthopedic value. The primary use apart from the medicinal purpose of some of the plants is vegetables, fruits, fibers, and stimulants, respectively (Table 2).

The method of preparation of the identified plants is shown in (Table 3). The various plant parts, such as the leaves, stems, and roots of the plants, were found to be used in the preparation of the herbal mixtures for the management of bone fractures. Also, leaves poultices of *N. laevis* were used to treat a dislocation, heal damaged connective tissue, and stop sepsis.

Table 2. Abundant status and habit of the plants used for traditional bone in the study area

Botanical name	Family name	Habit	Vernacular/Ijaw name	Abundant status
Abelmoschus esculentus (L.)	Malvaceae	Shrub	Okro/ Kiyabu	Abundant
Aframomum melegueta (K.Schum.)	Zingiberaceae	Herb	Alligator pepper/ Sani	Abundant
*Alchornea cordifolia (*Mull. Arg.)	Euphorbiaceae	Shrub	Adeginapumue	Abundant
Alternanthera sessillis (L R.Br. ex DC).	Amaranthaceae	Herb	Canapunu	Abundant
Amaranthus viridis (L.)	Amaranthaceae	Herb	Green amaranth /Enina	Abundant
Capsicum annuum (L.)	Solanaceae	Herb	African pepper/Egina	Abundant
Carica papaya (L.)	Caricaceae	Herb	Pawpaw /Edemudepumue	Abundant
Ceiba pentandra (L).	Malvaceae	Tree	Cotton tree/ Asisaye	Rare
Citrus aurantifolia (Christm) Swingle	Rutaceae	Tree	Lime leave/Ongoberi	Frequent
Cleome ciliate (L.) Briq.	Cleomaceae	Herb	Cleome/Kakagben/ Agbalala	Abundant
Costus afer (Ker. Gaw.l)	Costaceae	Herb	Ginger lily/Ogbodo	Abundant
Cyathula prostrata (Linn.)	Amaranthaceae	Herb	Pasture weed/ Oborikorigha	Abundant
Cymbopogon citratus (DC.) Stapf.	Poaceae	Herb	Lemon grass/Bekepiri	Abundant
*Diodia sarmentosa (*Sw.)	Rubiaceae	Herb	Button weed/Iyaimo, Ikinrinrin	Abundant
Eclipta alba(L).	Asteraceae	Herb	Eclipta/Ekigaliapumue	Abundant
Elaeis guineensis (Jacq.)	Arecaceae	Tree	Oil palm/ Lobolou, Lugutin	Abundant
Eleusine indica (Linn.)	Poaceae	Grass	Bermuda grass/Agolo	Abundant
Ficus lutea (Vahl.)	Moraceae	Tree	Lagos rubber tree /Ula, Native pop	Rare
Garcinia kola (Heckel.)	Guttiferae	Tree	Eka/Bitter kola	Rare
Glyphaea brevis (SprengMonach.)	Tiliaceae	Tree	Itolo	Frequent
Harungana madagascariensis Lam. ex Poir.	Clusiaceae	Tree	Haronga/ Boopulo	Rare
Ipomoea batatas (L. Lam.)	Convolvulaceae	Vine	Pokueduku/Sweet potato	Abundant
Jatropha tanjorensis (Ellis & Saroja)	Euphorbiaceae	Shrub	Hospital too far	Abundant
*Kalanchoe pinnatum (*Lam).	Crassulaceae	Herb	Live leaf/Beri	Abundant
Ludwigia octovalvis(W.)	Onagraceae	Herb	Eviesaberi	Occasional
Mangifera indica (L.)	Anarcardiaceae	Tree	Mango/Ogune	Abundant
Mimosa pudica (L.)	Fabaceae	Herb	Sensitive plant/Igbanagbana, Dabomenetibigban	Abundant
Newbouldia laevis (Seem. ex Bureau.)	Bignoniaceae	Tree	Tree of live/Ogurizi	Abundant
*Ocimum gratissimum(*L).	Lamiaceae	Shrub	Scent leaf/Kara furu	Abundant
Phyllanthus amarus (Schum. &Thonn.)	Phyllanthaceae	Herb	Amarus/Tukaben	Frequent
*Piper guineense (*Schum. &Thonn.)	Piperaceae	Vine	African black pepper/Aziza, Uziza	Rare
*Portulaca oleracea (*L.)	Portulacaceae	Herb	Purslane/Kalaorwoegina	Abundant
Psidium guajava (L).	Myrtaceae	Tree	Guava/ Aguava	Abundant
Solenostemon monostachyus (P. Beaux.)	Lamiaceae	Herb	Catnip/Ipain	Occasional
Spondias mombis (L.)	Anacardiaceae	Tree	Cat's tail grass/ Owenyaiyaitogo	Frequent
*Theobroma cacao (*L.)	Malvaceae	Tree	Cocoa/Odukuku	Frequent
Vernonia amygdalina (Del.)	Compositae	Shrub	Bitter leaf/Kiriorugbo	Abundant
Xylopia aethiopica (Dunal) A. Rich.	Annonaceae	Tree	Ethiopian pepper / Enge	Rare
*Zingiber officinale (*Roscoe.)	Zingiberaceae	Herb	Ginger/Zinza	Rare

Table 3. Primary uses and Trado-orthopedic uses of the identified botanicals

Botanical name	Preparation and treatment	Primary use
A. esculentus	The fruits are crushed and the warm poultice is applied externally to soothe the stiffness of limbs and pushing dislocated bone back to its position.	Vegetable
A. melegueta	The seeds are externally used with native chalk as a poultice on the fractured areas for bone hardening and pain reliever.	Medicinal, spice
A. cordifolia	The leaves paste was applied externally over the fractured area to check infection and facilitate recovering	Medicinal purpose
A. sessillis	The pounded leaves paste applied in synergy with others (*C. aurantifolia, A. melegueta*, and *E. indica*) over the fracture for bone hardening, pain relief and antiseptic	Medicinal purpose
A. viridis	The pounded leaves paste is applied to reduce inflammations.	Vegetable
C. annuum	For treating sprain, arthritis and rheumatism, the fruits and leaves paste is applied on the affected areas.	Vegetable, spice
C. papaya	The poultice of the leaves is applied over the affected area to induce healing after pushing dislocated bone to its position	Fruit, medicinal use
C. pentandra	Pulverize the bark, and apply the alcohol infusion as a plaster on the dislocated area to treat the wound and reduces swollen	Fibers
C. aurantifolia	The leaves poultice is applied on the affected area to check for infection	Fruit
C. afer	Apply the squashed stem, fruit and leaves on the fracture to induce bone reunion.	Medicinal
C. prostrata	Apply the squashed leaves and the inflorescence on the fractured areas to treat wound and irritation	Medicinal, antidote
C. citratus	Used the leaves poultice for fracture, itching wounds and treating irritation.	Medicinal, spice
D. sarmentosa	Apply the squashed leaves on the sprain and the area affected by rheumatoid arthritis.	Medicinal
E. alba	Apply alcohol poultice of pulverized leaves on the dislocated area	Medicinal
E. guineensis	Apply the pulverized leaves on the dislocated area to induce bone mending. The frond rib is used as a splint	Vegetable oil
E. indica	The root poultice is applied to the affected areas to heal connective tissue damaged during fracture.	Medicinal
F. lutea	The stem serves as a local splint; the leaves are used in traction and stiffness of limbs. Applied on the affected part to induce quick reunification of bones	Medicinal
G. kola	Apply the alcohol poultice of the pulverized leaves on the fractured area to strengthen the bone after setting and prevent infection.	Stimulant, water treatment
G. brevis	Apply the pulverized leaves on the broken area for bone hardening and to reduce inflammation	Medicinal
C. ciliata	The fruit and leave poultice are applied on the area to prevent festering and to facilitate wound healing	None
H. madagascariensis	Applying the leaves poultice helps bone healing. The sap stops itching around the affected area.	Fuel wood, timber
I. batatas	The poultice of the leaves helps in bone healing and reduces inflammation	Vegetable
J. tanjorensis	Use the leave paste to stop bleeding and induce blood clotting.	Vegetable, medicinal
K. pinnatum	The leaves poultice is used to treat dislocation	Medicinal
Ludwigia octovalvis	The leave paste is applied on the affected area to treat the wound; it also serves as an analgesic	None
M.indica	Apply the leaves poultice on the broken area to enhance fracture mending and to harden merged bones	Fruit, medicinal
M. pudica	Used the leave paste in the treatment of inflammation around the affected area and stiffness of limbs	Medicinal
N. laevis	Use the leaves poultice to treat a dislocation, heal damaged connective tissue and stops sepsis.	Land border, medicinal
O. gratissimum	Extract from the leaves is applied to the fracture. It is used in synergy with other leaves	Spice
P. amarus	The poultice of the entire plant part is applied to the affected area to heal connective tissue damaged during bone fracture.	Medicinal
P. guineense	Apply the leaves and fruit poultice to treat inflammation in the dislocated area and stop itching	Spice, medicinal
P. oleracea	Apply the whole plant extract topically on the fractured area to relieve pain and hasten to heal	Vegetable
P. guajava	Use together with other herbs to harden bone and treat the wound.	Medicinal
S. monostachyus	The leave poultice is applied on the affected areas to reduce pain and heal the connective tissue affected.	Medicinal
S. mombis	The root and bark decoction is applied to reduce pain and stop sepsis.	Medicinal, ornamental
T. cacao	The seeds serve externally as soothing while massaging dislocated bone back to position	Stimulants, medicinal
V. amygdalina	The leaves poultice is applied in synergy with other herbs on the fractured area.	Medicinal
X. aethiopica	Use the crushed fruit paste in synergy with other herbs to treat fracture and dislocation	Spice, medicinal
Z. officinale	The fruit is externally used as a poultice on the fractured areas to induce bone healing and pain relief after the initial treatment.	Spice, medicinal

Similarly, the extract from the leaves is applied to the fracture. It is used in synergy with other leaves, such as *P. amarus*. The similarity in the use of the plants for traditional orthopedic care in the three LGAs is presented in Figure 2. Plants in Group E were reportedly used by all the respondents using TOCPs in the three LGAs; they applied the same way in preparing and treating bone fractures. However, their uses and wide acceptability as ingredients in bone treatment arise from the species' availability and effectiveness, although different approaches were applied in the administration. The previous assertion of Rakotoarivero et al. (2015) and Sheen and Garla (2019) opined that plants are commonly used among folks because of their efficacy for treatment. Traditional medicine has gained renewed interest in healthcare services throughout the continent. That could probably be due to the increasing awareness of alternative medicine's potential and curative abilities to manage different diseases, especially from medicinal plants.

Species in Group A, C, and G (on the Venn diagram) were peculiar by use to TOCPs in Yenagoa, S. Ijaw, and Kolokuma/Opokuma LGA, respectively. The peculiarity in using a plant species in rural societies could be attributable to custom, acceptability, and availability (Alam et al. 2016).

While the indigenous people enjoy enormous plant resources in their environment, the plants suffer depletion from extraction patterns that are either predatory or annihilative. Also, collection patterns observably involve stem and branch cutting and uprooting, making such collections devastating. That means harvesting results in the ruin of plants in their natural source, as a harvest involving stems, rhizomes, roots, bulbs, and barks seriously affects the mother plant's survival (Yirga and Zeraburk 1993). Also, such plants' regeneration rate always lags behind their extraction rate leading to the species' absence and death. As a result, prioritizing sustainable use and wilding of the species must be guaranteed by discouraging indiscriminate clearing of forests, discriminating bush burning at the local level, and creating awareness of the possible disappearance of the forest should the status quo persist.

In conclusion, this study highlighted new findings in the study area where plants such as *Abelmoschus esculentus* (L.), *Aframomum melegueta* (K.Schum.), *Alchornea cordifolia (*Mull. Arg.), *Alternanthera sessillis* (L R.Br. ex DC), *Amaranthus viridis* (L.), *Capsicum annuum* (L.), *Carica papaya* (L.), *Ceiba pentandra* (L), *Citrus aurantifolia* (Christm) Swingle, etc. are used as herbal medicine for managing bone fractures. It was shown that traditional herbal medicine practices to manage bone fractures existed in the study area. The plants are relatively available and effective. The knowledge of the preparation and mode of administration is well known to the indigenous people. Therefore, conservation strategies such as avoidance of cutting trees, efficient utilization of natural resources, and avoidance of conversion of forest reserves to subsistence farming systems should be put in place. However, the chemical compositions of the plants, in vivo, and computational studies of the plants should be assessed to validate their use scientifically.

REFERENCES

Abera B. 2014. Medicinal plants used in traditional medicine by Oromo people, Ghimbi District, Southwest Ethiopia. J Ethnobiol Ethnomed 10: 40. DOI: 10.1186/1746-4269-10-40.

Adedeji DE, Kayode J, Ayeni, MJ. 2018. An ethnobotanical study of plant species used for medicine by the Eegun indigenous tribal group of Lagos State, Nigeria. Not Sci Biol 10: 318-327. DOI: 10.15835/nsb10310306.

Ahmad M, Sultana S, Fazl-i-Hadi S, Ben Hadda T, Rashid S, Zafar M, Khan MA, Khan MPZ, Yaseen G. 2014. An Ethnobotanical study of medicinal plants in high mountainous region of Chail Valley (District Swat-Pakistan). J Ethnobiol Ethnomed 10 (1): 36. DOI: 10.1186/1746-4269-10-36.

Ajao AA, Mukaila YO, Sabiu S. 2022. Wandering through southwestern Nigeria: An inventory of Yoruba useful angiosperm plants. Heliyon 8: e08668. DOI: 10.1016/j.heliyon.2021.e08668.

Alam W, Shah FA, Ahmed A, Ahmad S, Shah A. 2016. Traditional bonesetters; frequency of complications with treatment by traditional bonesetter. Professional Med J 23 (6): 699-704. DOI: 10.17957/TPMJ/16.3354.

Aziz MA, Khan AH, Adnan M, Izatullah I. 2017. Traditional uses of medicinal plants reported by the indigenous communities and local herbal practitioners of Bajaur Agency, Federally Administrated Tribal Areas, Pakistan. J Ethnopharmacol 198: 268-281. DOI: 10.1016/j.jep.2017.01.024.

Az-Zahra FR, Sari NLW, Saputry R, Nugroho GD, Sunarto, Pribadi T, Setyawan AD. 2021. Review: Traditional knowledge of the Dayak Tribe (Borneo) in the use of medicinal plants. Biodiversitas 22: 4633-4647. DOI: 10.13057/biodiv/d221057.

Balick MJ, Cox PA. 1996. Plants, People and Culture: The Science of Ethnobotany. The Scientific American Library, New York.

Bannerman RH, Burton J, Chen WC. 1983. Traditional Medicine and Health Care Coverage: A Reader for Health Administrators and Practitioners. World Health Organization, Geneva. DOI: 10.2202/1553-3840.1025.

Brandão MGL, Acúrcio FA, Montemor RLM, Marlière LDP. 2006. Complementary alternative medicine in Latin America: Use of herbal remedies among a Brazilian metropolitan area population. J Complement Integr Med 3 (1): 2006 DOI: 10.2202/1553-3840.1025.

Chohra D, Ferchichi L. 2019. Ethnobotanical study of Belezma National Park (BNP) plants in Batna: East of Algeria. Acta Sci Natur 6 (2): 40-54. DOI: 10.2478/asn-2019-0017.

Dada AA, Yinusa W, Giwa SO. 2011. Review of the practice of traditional bone setting in Nigeria. Afr Health Sci 11 (2): 262-265.

Deressa W, Ali A. 2009. Malaria-related perceptions and practices of women with children under the age of five years in rural Ethiopia; BMC Public Health 9: 259. DOI: 10.1186/1471-2458-9-259.

El-Ghani MMA. 2016. Traditional medicinal plants of Nigeria: An overview. Agric Biol JN Am 7: 220-247.

Erinoso S, Aworinde D. 2018. Current outlook and future promise of ethnobotany in Nigeria: A review and personal observation. Afr J Plant Sci 12: 73-80. DOI: 10.5897/AJPS2017.1571.

Esrafilian A, Karimi MT, Amiri P, Fatoye F. 2013. Performance of subjects with knee osteoarthritis during walking: differential parameters. Rheumatol Intl 33 (7): 2753-1761. DOI 10.1007/s00296-012-2639-2.

Gaddy HG. 2020. Using local knowledge in emerging infectious disease research. Soc Sci Med 258: 1-5. DOI: 10.1016/j.socscimed.2020.113107.

Gureje O, Nortje G, Makanjuola V, Oladeji, B, Soraya S, Jenkins R. 2018. The role of global traditional and complementary systems of medicine in treating mental health problems. Lancet Psychiat 2 (2): 168-177. DOI: 10.1016/s2215(15)00013-9.

Hong LY, Guo ZY, Huang KH, Wei SJ, Liu B, Meng SW, Long CL. 2015. Ethnobotanical study on medicinal plants used by Maonan people in China. J Ethnobiol Ethnomed 11: 32. DOI: 10.1186/s13002-015-0019-1.

Huai HY, Pei SJ. 2002. Medicinal Ethnobotany and its advances. Chin Bull Bot 2 (19): 129-36.

Ihinmikaiye SO, Ochekwu BE, Ikuli JM. 2020. Ethnobotanical studies on floras used for storage in Bayelsa State, Nigeria. Sci Res J 8 (12): 29-34. DOI: 10.31364/SCIRJ/v8.i12.2020.P1220826.

Ihinmikaye SO, Akinjagunla AD. 2020. Ethnobotanical survey of medicinal plants used by the indigenous people of Bayelsa State, Nigeria. IJEAST 5 (1): 771-784. DOI: 10.33564/IJEAST.2020.v05i01.135.

Kidane L, Gebremedhin G, Beyene T. 2018. Ethnobotanical study of medicinal plants in Ganta Afeshum District, Eastern Zone of Tigray, Northern Ethiopia. J Ethnobiol Ethnomed 14: 64. DOI: 10.1186/s13002-018-0266-z.

Lawal IO, Olufade II, Rafiu BO, Aremu AO. 2020. Ethnobotanical survey of plants used for treating cough associated with respiratory conditions in Ede South Local Government Area of Osun State, Nigeria. Plants 9: 647. DOI: 10.3390/plants9050647.

Liu Y, Dao Z, Yang C, Liu Y, Long CL. 2009. Medicinal plants used by Tibetans in Shangri-la, Yunnan, China. J Ethnobiol Ethnomed 5 (1): 15. DOI: 10.1186/1746-4269-5-15.

Martin GJ. 1995. Ethnobotany: A Methods Manual. Chapman and Hall Pub., London.

Mukaila YO, Oladipo OT, Ogunlowo I, Ajao AAN, Sabiu S. 2021. Which plants for what ailments: A quantitative analysis of medicinal ethnobotany of Ile-Ife, Osun State, southwestern Nigeria. Evid-Based Complementary Altern Med 2021: 5711547. DOI: 10.1155/2021/5711547.

Olanipekun MK, Otoide JE, Adedeji E, Amoo JA, Olajumoke DA. 2020. Assesment of bioactive of compositions of selected plants used in managing hypertension conditions in Osun State Nigeria. Res J Med Plant 13 (13): 5-42. DOI: 10.3923/rjmp.2020.35.42.

Onuminya JE. 2004. The role of the traditional bonesetter in primary fracture care in Nigeria. S Afr Med J 94 (8): 652-658.

Rakotoarivero NH, Rakotoarivony F, Ramarosandratana AV, Jeannoda VH, Kuhlman AR, Randrianasolo A, Bussmann RW. 2015. Medicinal plant used to treat the most frequent diseases encountered in Ambalabe rural community, Eastern Madagascar. J Ethnobiol Ethnomed 11: 68. DOI: 10.1186/s13002-015-0050-2.

Sheen JR, Garla VV. 2019. Fracture Healing Overview. InStatPearls (internet). Treasure Island (FL) StatPearls Publishing LLC. Available from: pubmed.ncbi.nlm.nih.gov/31869142

Sonibare MA, Gbile ZO. 2008. Ethnobotanical survey of anti-asthmatic plants in South Western Nigeria. Afr J Tradit Compl Altern Med 5: 340-345. DOI: 10.4314/ajtcam.v5i4.31288.

Su SL, Zhang TT, Zhang B, Huang K, Zeng XB. 2011. Ethnobotany study in the minority area of Baise region. Anhui Agri Sci Bull 17 (23): 123-4 142.

Suchita T. (2019. Ethnomedicine and future challenges. Glob J Arch Anthropol 10 (5): 555796. DOI: 10.19080/GJAA2019.10.555796.

Teshome W. 2005. Impacts of urbanization on the traditional medicine of Ethiopia. Anthropologist 8: 43-52. DOI: 10.1080/09720073.2006.11890933.

Tewelde F, Mesfin M, Tsewene S. 2017. Ethnobotanical survey of traditional medicinal practices in Laelay Adi-Yabo District, Northern Ethiopia. Intl J Ophthalmol Visual Sci 2 (4): 80-87. DOI: 10.11648/j.ijovs.20170204.11.

Tilahun TJ, Moa M. 2018. Ethnobotanical study of medicinal plants used to treat human diseases in Berbere in Berbere district, Bale zone of Oromia regional State, South East Ethiopia. Evid-Based Complement Altern Med 2018: 8602945. DOI: 10.1155/2018/8602945.

Tugume P, Kakudidi EK, Buyinza M, Namaalwa J, Kamatenesi M, Mucunguzi P, Kalema. 2016. Survey of medicinal plant species used by communities around Mabira Central Forest Reserve, Uganda. J Ethnobiol Ethnomed 12 (1): 5. DOI: 10.1186/s13002-015-0077-4.

Upadhya V, Hegde HV, Shripad B, Hurkadale PJ, Kholkute SD, Hegde GR. 2012. Ethnomedicinal plants used to treat bone fracture from North-Central Western Ghats of India. J Ethnopharmacol 142: 557-562. DOI: 10.1016/j.jep.2012.05.051.

Vibhi. 2017. Medicinal plants and bone healing. Natl J Maxilofac Surj 8 (1): 4-11. DOI: 10.4103/0975-5950.208972.

Vinayak U, Harsha UH, Shripad B, Pramod JH, Kholkute SD, Hegde GR. 2012. Ethnomedicinal plants used to treat bone fracture from North-Central Western Ghats of India. J Ethnopharmacol 142: 557-562. DOI: 10.1016/j.jep.2012.05.051.

Yirga G, Zeraburk S. 2011. Ethnobotanical study of traditional medicinal plants in Gindeberet district, Western Ethiopia. S Afr J Bot 78: 165-169. DOI: 10.1016/j.sajb.2011.06.006.

Zhu YP, Woerdenbag HJ. 1995. Traditional Chinese herbal medicine. Pharm World Sci 17 (4): 103-112. DOI: 10.1007/BF01872386.

ASIAN JOURNAL OF ETHNOBIOLOGY
Volume 5, Number 2, November 2022 E-ISSN: 2580-4510
Pages: 138-155 DOI: 10.13057/asianjethnobiol/y050207

Ecology of village ecosystems of Odisha, India

V. P. UPADHYAY[1,♥], B. K. NAYAK[2], M. K. MISHRA[2]
[1]B1/303 NJBM Society. Maitri Vihar, Bhubaneswar-751023, India. ♥email: vpupadhyay@gmail.com
[2]Department of Botany, Berhampur University. Bhanja Bihar, University, Pin-760007, Brahmapur, Odisha, India

Manuscript received: 24 September 2022. Revision accepted: 25 November 2022.

Abstract. *Upadhyay VP, Nayak BK, Mishra MK. 2022. Ecology of village ecosystems of Odisha, India. Asian J Ethnobiol 5: 138-155.* The present study was conducted in eight villages in the Niyamgiri Hills of Odisha, India. The human population varies from 83 to 312 in uphill villages and 76 to 150 in foothill villages. The cultivated area constitutes 3.37% to 18.85% of the village's total area. Per capita cultivated area varies from 0.117 to 0.329 ha. The families generally devote more time to agriculture, followed by Minor Forest Products (MFP) collection. The women and children collect leafy vegetables, tubers, fruits, seeds, leaves, and flowers. Collecting and marketing firewood in head loads is commonly practiced in the rainy season. The area of forest cover is not affected much, but the quality of the forest has changed. This suggests appropriate steps to restore the forest and enhance its productivity. All villages depend on rain-fed agriculture. The natural stream water is available to the paddy fields by gravity flow in valleys. The agriculture practices include shifting (podu) cultivation in high hill areas, mid-hill orchards below the podu area, home gardens adjoining habitation, and valley cultivation near Nala beds (streams). Podu is a mixed cultivation practice where cereals, pulses, and oil seeds are grown together. The village productivity is much lower than in other areas of settled agriculture. Improvements in seed quality, Soil and Moisture Conservation (SMC) measures, and the health condition of the tribal community will help support the sustainability of the traditional cultivation and livelihood system. To help protect the indigenous biodiversity, we suggest in this paper other alternatives of livelihood to the local population and options for shifting cultivation areas.

Keywords: Common property resource, forest, livelihood minor forest produce, Niyamgiri, Odisha, podu cultivation, tribal

INTRODUCTION

The practice of conversion of natural tropical forests to agriculture by landless people is prevalent in many countries (Anderson 1990; Schenldar 1995). The ecosystem is dynamic, and we need to adopt model cultivation practices in tropical areas to counter the adverse impact of the converted ecosystem (FAO 1993; Aida et al. 2016). The human-environment relationship can be studied at the socio-economic and cultural levels, emphasizing the production and consumption of biomass energy and highlighting the developmental opportunities existing within the ecosystem (Sahoo and Misra 1992; Rao et al. 2003). A tribal village is considered an ecosystem by considering its biomass production, consumption, and energy dynamics in terms of import and export (Nisanka and Misra 1990; Nayak et al. 1993). In India, the tribal village ecosystem functions mainly by recycling resources within the system (Mishra and Ramakrishnan 1982.). Biomass energy and human labor are two main driving forces for the functioning of an agriculture-based village ecosystem (Nisanka and Misra 1989; Rao et al. 2000). There have been efforts by ecologists to correlate the changes in plant-animal diversity with different scales of natural/anthropogenic disturbances (Van Der Maarel 1993; Nautiyal et al. 2003; Maikhuri et al. 2004). The agroecosystem concept provides a framework to analyze the food production system as a whole, including its complex set of inputs and outputs and the interconnection (Gliessman 2007). Traditional agriculture is comparable to natural ecosystems, not only in physical structure but also in terms of an organic environment, disease resistance, higher biodiversity, and stability. Even if it is a rain-fed condition, its sustainability is proven over centuries. Small tropical farmers without the knowledge of taxonomy unknowingly conserve biodiversity, indirectly contributing priceless donations to the gene pool. These are extremely poor people whose livelihood depends on the vast, diverse, and risk-prone marginal environment (Conway 1997). An ecological approach is needed to develop a system and technology that suits small farmers' specific environmental and socio-economic conditions without increasing risk or dependence on external inputs. Agroecosystems should be resource-conserving yet highly productive systems such as polyculture, agroforestry, and integration of crops and livestock (Altieri 1995). Traditional resource management adaptations such as agroforestry systems may provide options for livelihood improvements through the simultaneous production of food, fodder, and firewood, as well as mitigation of the impact of climate change (Rabindranath and Hall 1995).

More diverse agroecosystems have better control over pests and diseases through the favorable environment for the natural enemies of pests and resistance of different species to the spread of disease (Landis et al. 2000). Monoculture, with reduced structural and functional diversity has low resiliency than natural ecosystems. Growing demand for food coupled with land and water management practices that cause degradation and erode natural resource bases simultaneously put sustainable

pressure on the ecosystem services (Abel et al. 2003). Bennett et al. (2005) pointed out that with the growing demand for food production and water use, demands for other ecosystem services, in many cases, will be beyond the capacity of certain ecosystems to supply. The planners have to assess the production of various services in the ecosystem on the one hand and the social and economic benefit and the risk of using technology to provide them on the other (Bennett et al. 2005). Scientists have evolved diverse agroecosystems, some of which are rich in biodiversity and provide ecosystem services, including food production (Jarvis et al. 2007). Agroforestry system may provide part of the answer to the challenge of sustainability on how to conserve forest ecosystem and farmland biodiversity as well as services they provide, including enhancing food production for an increasing population under the condition of land and water scarcity (Godfray et al. 2010; Lambin and Meyfroidt 2011; Phalan et al. 2011). A more biologically complex system will provide short and long-term environmental and socio-economic benefits, or ecosystem services, such as enhanced food security and agricultural resilience to environmental change (Altieri 1980; Tomich et al. 2011).

In the present study, we conducted research in eight villages closely connected to the natural ecosystem and where social activities and ecological processes are closely interrelated. The results presented here include an in-depth analysis of human-ecosystem functioning and benefits derived by the society including biomass used as food, fuel, fiber and construction materials. Thus, this case study aimed at gathering information on agroecosystem functioning around Niyamgiri Forests to address the above issues and to suggest how conservation objectives can be achieved by making village ecosystem compatible to ecological requirements. The main objective of the present program was to study the village ecosystem in and around Niyamgiri Hill Forest with an integrated view of all conditions and influences. Furthermore, the sustainability of the agroecosystem, its dependency on the forest ecosystem, and the community's economic development were studied in terms of resource management.

MATERIALS AND METHODS

Study area and environment

There are about 164 villages in and around Niyamgiri Hill Range, India, deriving their livelihood from forest resources. The practice and traditional agriculture in the vicinity are prehistoric. However, the magnitude of changes in the inter-dependency of agroecosystem and forest ecosystems has led to ecological and economic deterioration. Therefore, studies of ecosystem linkages and socio-cultural changes are essential to developing a strategy to arrest further degradation of the ecosystem and suggest priority sectors for improvement. The study sites are located around Niyamgiri Hill Ranges in four blocks (Figure 1). Eight villages were selected for the study, out of which four village settlements are situated at higher elevations inside Niyamgiri Forest, and four village settlements at the foothill, out of which two are closer to the marketplace (urban area) and two are a little away from the urban area. The village settlements are Villages inside Niyamgiri Hill Forest at higher altitudes: Patlamba, Khajuri (Figure 2), Rodanga (Figure 3), Gortali; Villages outside the Niyamgiri hills away from the marketplace (Majhihalma, Bhaliabhatta); and Villages outside the Niyamgiri hills nearer to the market place (D. Kumbharbadi, Papikhunti).

Niyamgiri forest lies between 83°17' to 83°29' E Long and 19022' to 19°- 42'N Lat. Most of the forest remains un-surveyed due to inaccessibility. Only a few Reserve Forest (RF) and Proposed Reserve Forest (PRF) exist in the Niyamgiri Hill Range, covering 125.86 sq. km (Tables 1 and 2). Varied topography with continuous valleys and ridges and unbroken mantle of forest supports very rich biodiversity, involving tropical and sub-tropical species. It is the cradle of major rivers of Rayagada District, with Bansadhara in the north and Nagabali in the south, which flows to the Bay of Bengal through Andhra Pradesh, Niyamgiri Hill Forest is elongated in a north-south direction (ca 36 km) with an average width of about 15 km and encompasses about 496 sq km area. The altitudinal variation is from 400 m to 1516 m, responsible for varied vegetation, higher rainfall, and cooler micro-climate with perennial streams. Niyamgiri hill range is an extensive area with degraded *Shorea robusta* (sal) forest interrupted by shifting (*podu*) cultivation practices in the habitation areas. Inhabitants in the range are the Kandha Tribe, namely 'Dongria Kandha'- a primitive tribal group settled near perennial streams in high altitude areas (600-700 m). In the region, the microclimate effect is revealed with a cooler climate, more rainfall than adjoining areas and rich biodiversity. Difficult terrain footpaths connect the settlements. All weather roads are a recent development to peripheral villages otherwise, the vast tract of land is almost virgin. Shifting cultivation provides food and fodder to the people, and the forest provides additional support with tubers, fruits, and leafy vegetables besides fuel wood, housing materials, agriculture implement and grazing land.

Climate

The monthly variation in temperature indicates seasonal changes (Table 3). Three seasons are distinct. The minimum temperature was recorded during January (6.2°C) and the maximum temperature during June (45.6°C). Niyamgiri hill ranges experience a monsoon climate from mid-May to mid-October which is more than the normal monsoon period of three months. The average rainfall of the district varies from 1013.66 mm to 1491.4 mm over 5 years i.e., 2009 to 2013 (Table 4). The rainfall spreading over five months creates a micro-climate in the area which has highly diverse vegetation. Most streams are perennial in nature, and the inhabitants use the water for domestic purposes and irrigation. The forest vegetation is miscellaneous, with intermittent sal forest with its associates. The relative humidity observed at 8.30 AM and 5.30 PM indicates the climatic status of the locality. The monthly average relative humidity information recorded for the district is presented in Table 5.

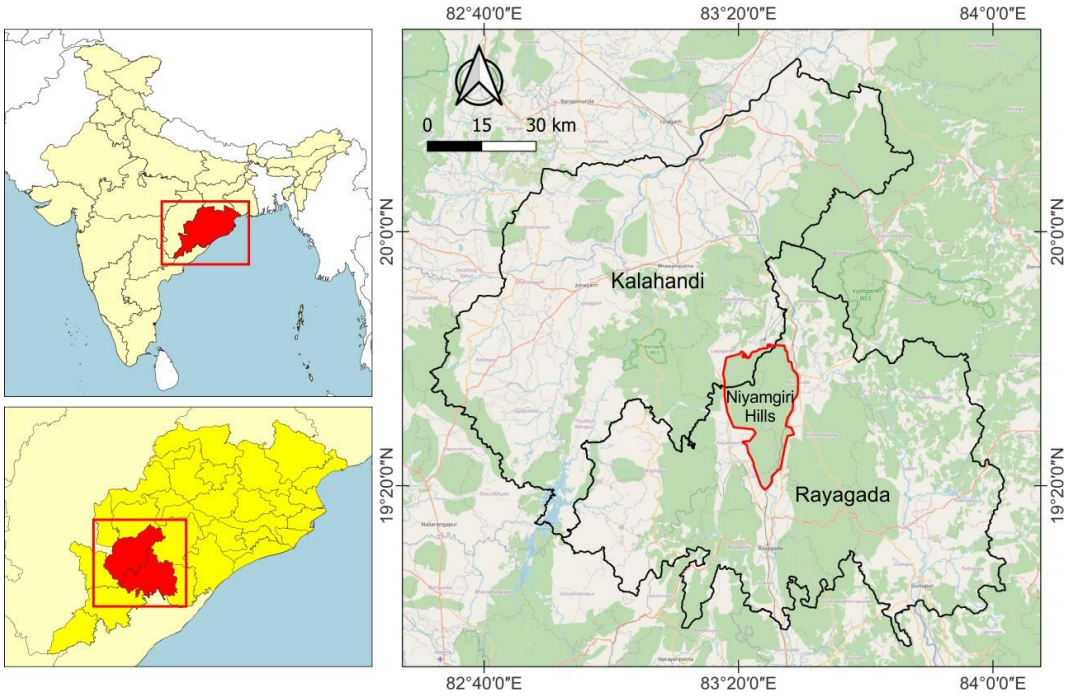


Figure 1. Location of Niyamgiri Hills in the District of Rayagada and Kalahandi, India

Figure 2. Uphill Village Khajuri, India

Figure 3. Common Worship place of Village Rodanga, India

Table 1. Reserve Forest (RF) and Proposed Reserve Forest (PRF) area in the Niyamgiri Hill, India (Source: Rayagada and Kalahandi (s) Forest Divisions)

Name of RF/PRF	Area (ha)	Remarks
Khambasi PRF	693.00	Muniguda range, Rayagada District
Nimagiri PRF	2810.93	K. Singhpur range
Karanja RF	607.29	(total area= 6124.58 ha)
Kansaralu RF	839.56	Rayagada District
Kansaralu extn RF	105.26	
K.Singhpur RF	323.88	
Sajja PRF	1236.03	
Satabisi PRF	201.62	
Niyamgiri RF	2100.00	Biswanathpur range
Tiramunhi PRF	536.65	(total area= 5768.65 ha)
Nachinigurah RF	1298.00	Kalahandi District
Jalakrirha RF	1834.00	

Table 2. GPS location of studied villages at Niyamgiri, Odisha

Name of villages	Latitude	Longitude	Alt. (m)	Remark
Patlamba	19^0 29' 2''	83^0 25'51''	550	Inside villages
Khajuri	19^0 30' 1''	83^0 25'44''	687	of Niyamgiri
Gartali	19^0 30' 57''	83^0 26' 3''	812	at higher
Rodanga	19^0 29'28''	83^0 25'27''	647	elevation
Kumbharbadi	19^0 28'36''	83^0 26'54''	435	Outside
Papikhunti	19^0 27'42''	83^0 26'39''	419	villages at foot
Majhialma	19^0 27'39''	83^0 26'40''	411	hills
Bhalibhatta	19^0 28'24''	83^0 27'10''	423	

Table 3. Annual temperature (°C) at Niyamgiri during 2009 to 2013

	2009		2010		2011		2012		2013	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
January	6.7	32.3	6.5	31.2	6.2	34.1	6.8	33.2	6.3	31
February	11.5	33	10	37	11.2	29.1	10.5	36	10	34.2
March	14	42	16	41.2	15	40	15.5	42.2	16.2	42
April	21	41.5	22	44	20	40.5	21.5	43	20.2	43.6
May	22.5	44.2	23.5	45.5	21.5	43.5	22	44.5	24	45
June	21.2	43	20.2	45.6	24	41	23	45	21.5	44.2
July	22.2	35	23.2	35.5	21.5	36	21.5	34.5	22	37
August	23.5	36	23.2	35.2	23	35	22.2	36.5	23.2	35.2
September	20	34.5	20	34.2	21.5	34.2	20.5	33	21	33.5
October	16	35.6	17	34.2	15.5	35.6	16	34	16.5	35
November	14.5	33.5	16	33	12.5	34	13	32	15	34
December	8	30	7.7	31.1	7.8	32.2	7.2	30.2	7.5	31.2
Annual	6.7	44.2	6.5	45.6	6.2	43.5	5.8	44.5	6.3	44.2

Table 4. Annual average rainfall (mm) and rainy days

	2009	**2010**	**2011**	**2012**	**2013**
January	0	31.90	0	20.07	0.6
February	29.2	0	20.7	2.3	8.1
March	1.0	3.2	0.6	1.37	1.5
April	90.9	24.8	23.59	12.25	54.4
May	74.2	97.7	20.99	8.21	9.5
June	200.5	144.6	177.64	214.95	170.45
July	155.8	392.5	219.71	335.69	318.77
August	350.8	313.8	279.11	205.94	295.16
September	248.4	215.6	234.7	221.29	133.85
October	14.5	179.5	34.02	48.2	152.97
November	0.0	43.3	0.1	47.37	1.8
December	0.5	44.5	2.5	0	0
Total	1165.8	1491.4	1013.66	1117.64	1147.1

Table 5. Relative humidity (%) changes during the year in study region of Niyamgiri Hills, India

	2009	**2010**	**2011**	**2012**	**2013**
January	63	67	58	67	64
February	51	51	61	52	56
March	41	43	49	40	42
April	43	47	59	47	49
May	51	54	48	46	49
June	54	64	66	58	69
July	85	85	74	77	75
August	83	81	81	80	78
September	79	82	79	79	78
October	70	81	74	73	84
November	79	82	71	72	69
December	70	71	68	62	65

Methodology for study

Data on the socio-ecological structure and functioning of eight villages were collected through questionnaire-cum-schedule method (Mitchell 1979; Nisanka and Misra 1990; Nayak et al. 1993; Sahoo 1993). These publications were considered while preparing the questionnaire and collecting socio-economic and ecological data of the selected villages during 2010-2015. The boundaries of the villages were defined with the help of the state revenue map. The sampled villages were visited regularly for data collection based on the inhabitants' availability. The survey information was collected by interviewing the family heads. In addition, sample weighing of humans, animals, and materials was done in the field.

Human population and socio-economic structure

The human population was calculated from the total family members of the villages. The literacy rate was determined by interviewing the heads of the family. The questionnaire forms were filled up by getting information from the family heads about their occupation, source of income, materials used in day-to-day life and construction of houses, cultivation and agricultural products, market, and sale of available surplus products after self-use, etc. Land ownership determines the status of the family in the tribal villages. Since shifting cultivation is commonly practiced in hilly tracks, the information on shifting cultivation was collected in detail through field visits, the inputs and outputs for different crops were recorded, including home garden and valley cultivation. The horticulture products that support most families' economies are orange, pineapple, banana, mango, litchi, etc. The crop residues used as soil fertilizer or fuel wood were also recorded. In addition, the annual production of dung used as organic fertilizer was recorded.

Forest resources, plant biomass and productivity

The community's dependency on the forest was evaluated by collecting information on minor forest produce and varieties of food products derived from the forest. The requirement of small timber, firewood, bamboo, etc., for the house construction, is also noted. The production of the sap of *Caryota* palm was estimated from the persons collecting the sap during the winter season. The above-ground biomass of crops grown in shifting cultivation areas, home gardens and valley areas was estimated in the field at harvest time. The biomass of individual crops raised by the villagers was measured at harvest time, and the total production of biomass of each family was recorded. The individual biomass production

was added to get the total village biomass production (t ha^{-1}). The productivity was calculated for the total production of the village crop-wise and divided over the cultivated area to get the average productivity of the village. The surplus agricultural products are normally sold in the nearest weekly market (Chatikona). The villagers meet the market demand for different forest produce every week or when required. This provides economic support and eligibility to purchase his/her family requirement from the market. The information on villagers' sales and purchase of different commodities was recorded. Domestic animals like cows, buffalo, goats, sheep, and pigs are commonly kept by villagers, along with local poultry varieties. The information collected through the questionnaire was recorded.

Among the forest produce, fuel wood and fodder are major biomass components followed by a small timber, bamboo, and food products (tubers, seed, fruit, leafy vegetables, etc.). Individual household data collected from each village were consolidated for comparison. The food consumption was calculated depending on the total production for agriculture, forest animal husbandry, etc., excluding the products sold in the weekly market or village itself as surplus only. The food grain, vegetables, etc., purchased from the weekly market or public Distribution System (PDS) was added to the quantity consumed. In agriculture, the crops are produced in different seasons. The grains and residues were sampled to assess the total production. Tubers and leafy vegetables are collected during the rainy season before the crops are harvested. This was estimated by family-wise daily collection, which is rarely sold, almost all consumed. Domestic animals like cattle, goats, sheep, buffalo, etc., graze in the adjoining forest. No stall-feed is provided. The quantity of fodder consumed was assessed by the intake capacity of animals based on average body weight. The quantity of fuel used in a family was estimated by head load-wise consumption for several days. The average head load weight was measured and given to different family-sized households (family members) in each village to estimate different consumption rates. Kerosene was given through PDS in a monthly quota used in the family. The sap of *Caryota* palm (salapa) is collected locally by limited members of the villagers and sold locally. The quantity of liquor production was estimated by the number of fully grown plants present in the village area. The collection period starts after the rainy season and continues through winter up to summer. The consumption rate was estimated by counting the number of individuals using the salapa sap and the quantity of sap produced. Elderly persons commonly use black cigars from the Tobacco leaf grown in the village. It is grown in the periphery villages of Niyamagiri, but not uphill villages inside Niyamgiri and is used by both male and female adults. The uphill villager does not grow Tobacco but purchases it from the weekly market. Women more commonly use black cigars.

Waste of biomass and material flow

The crop residue left in the field was collected in a sample area and weighed to assess the total residue left in the fields. The use of fodder and grain by birds, rodents, insects, etc., was not considered. The materials sold /exported by villagers and purchased from the outside market were recorded through a questionnaire by contacting each family. The self-sufficiency of the ecosystem was calculated based on the import/ export data of individual villages. Total hours spent for each crop were calculated considering the respective crop area. Total human hours (men, women, and children) spent on the collection of minor forest products were estimated by counting the hours spent per day by individuals of each category and the total collection days during the year. This was based on the information collected from family heads and weekly observations. Participatory Rural Appraisal (PRA) method was used to study villages' status of Common Property Resource (CPR). The objective of studying the status of CPR was to understand the functioning of traditional society living in village clusters i.e., the traditional land management practice for agriculture and animal husbandry, the interdependence of forest and other land management systems and the role of CPR in making the village self-sufficient.

RESULTS AND DISCUSSION

The villages under study are located in forest pockets in such a manner that the hilly topography and vegetation demarcate their boundaries. The villages are widely separated from each other, perhaps to avoid conflicts on natural resources available in the forest ecosystem. However, the forests beyond the boundary were used for shifting cultivation and collection of minor forest produce. This boundary extends up to the point of activity of the inhabitants. Structural components of the village ecosystem and various socio-economic factors were individually surveyed for ecological studies. The structural analysis mainly includes land use patterns, population and practices, housing patterns, and physical resource bases of the villages. The geographic area of the 8 villages is presented in Table 6 with the break-up of components under housing and cultivation (home garden, shifting cultivation and valley cultivation). Per head cultivated area varies by 0.117 ha (Patlamba) to 0.329 ha (D. Kumbharabadi). Shifting cultivation is prominent in four villages in the upper hill area (i.e., Patlamba, Rhodanga, Khajuri, and Gortali). The forest area is utilized for shifting cultivation and home garden. Paddy cultivation is observed in one upper hill village (Rhodanga) and three-foot hill villages (Majhihalma, Bhaliabhatta, and D. Kumbharabadi).

Human population and literacy

The human populations of villages were calculated from the household survey of family details. The male-female ratio indicates the female population is bigger in all villages except Papikhunti. The ratio is higher in four hilly villages, where male persons die at lower age as reported by old persons. The average family size varies from 3.8 to 5.2. The literacy rate varies widely from 4.8% in Patlamba to 72% in D. Kumbharbadi. Elder persons above the age

group of 40 years are totally illiterate in uphill villages. Only in recent years have schooling facilities developed. Adults aged 25-30 years have some primary education (Table 7).

Land use pattern and land ownership

The topography plays a major role in the land use by villages. Easy gradient slopes with soil cover are mostly used for raising crops under shifting cultivation. This provides basic food to the communities. It is always a polyculture type with temporal and spatial arrangements. Complex cropping is a traditional practice with many ecological and economic advantages. It is locally known as "Dongar" cultivation. All cereals, pulses, and oil seeds are grown here. It is only in rain-fed conditions. The second category of land is the valley area known as "Gudia" or "Padar" which is mostly used for ginger and turmeric, with some fruit plants surrounding the field or cottage. The land is mostly used for different cash crops like banana, orange, mango, litchi, jackfruit, etc.

The third category of land used for cultivation is the Nala-beds / aquatic areas with a perennial water flow mostly used for paddy. The low-elevation villages in the periphery of Niyamgiri practice paddy cultivation using stream water in very small patches with all uncertainty. Continuous rainfall in hilly areas promotes speedy flow in Nala-beds, at times washing all crops. Thus, three major categories of land are available for agricultural use. The homestead area of villages is very small, with compact houses in rows facing each other with a commonplace. The aquatic area is limited to the flow of mostly perennial streams. The major common property resource is forest land and uncultivated area. Nowadays, bore-well has been provided to the villages for drinking water. But the practice of using Nala water for all purposes is still prevalent. In some places, Dongaria Kandha Development Agency (DKDA) has provided an irrigation facility for horticulture crops. The clean stream water is supplied to the urban community at Bissam-Cuttack through gravity flow at a distance of about 10-12 km.

The area of the villages/settlements, as in official records, has little relevance to the use by the village community. The 'Dongaria' community of the hills does not feel the differential use of Government or private land. According to the ownership of the land area, the families of each village are grouped into four categories, i.e., (i) landless, (ii) Less than one ha, (iii) between 1-2 ha, and (iv) more than 2 Ha. These classifications are based on the revenue records with the forest right area of the families (Tables 8 and 9). The uphill villagers mostly use Government Forest lands for shifting cultivation and horticulture crops, which has no relationship with the above classifications. The foothill villagers are mostly restricted within the revenue-recorded land and rarely use forest land for raising crops. Unlike foothill villages, the uphill families have been given forest right titles under Forest Right Act.

Table 6. Structural analysis of village ecosystem

Village data	Villages							
	P	**R**	**K**	**G**	**M**	**B**	**D**	**H**
Total household	22	60	61	39	36	18	26	16
Total human population	83	279	312	201	150	90	100	76
Total male	32	129	140	87	72	44	47	45
Total female	51	150	172	114	78	46	53	31
Male: female	1:1.59	1:1.16	1:1.22	1:1.31	1:1.08	1:1.04	1:1.12	1:0.68
Average family size	3.8	4.65	5.1	5.2	4.2	5.0	3.8	4.8
Literacy rate (%)	4.8	21.86	39.4	13.9	48.0	21.1	72.0	50.0
Total livestock population	200	218	334	383	341	112	131	176
Cow	4	16	22	25	39	0	29	21
Bullock	0	6	0	0	0	19	0	6
Buffalo	0	7	0	0	0	7	0	16
Goat	83	51	67	86	78	13	42	26
Sheep	0	33	0	0	0	0	0	2
Poultry	90	90	77	173	140	73	37	99
Pig	23	15	168	99	84	0	23	6
Land use pattern								
Total land area (ha)	157.97	297.75	307.66	259.23	624.17	60.61	250.16	173.72
Aquatic	0	0	1.15	0	0	0.52	2.12	0
Housing	0.06	0.29	0.36	0.36	0.33	0.40	0.17	0.16
Up hill shifting cultivation	5.46	13.52	19.14	14.21	9.028	4.129	7.854	7.328
Mid hill (orchard)	3.1	27.83	36.68	20.43	0.1	0.04	0.1	0.06
Home garden (vegetables)	0.61	5.18	3.24	3.04	8.06	3.40	7.11	15.20
Valley paddy	0	7.22	0	0	10.84	3.46	13.07	0.00
Valley maize	0.566	1.235	10.809	9.514	8.016	4.574	4.777	0.554
Per capita agricultural land orchard (ha)	0.117	0.197	0.223	0.234	0.240	0.173	0.329	0.304

Notes: P: Patlamba, R: Rodanga, K: Khajuri, G: Gortali, M: Majhihalma, B: Bhaliabhatta, D: D. kumbharbadi, H: Papikhunti

Table 7. Distribution of households according to land holding capacity in Patlamba, Rodanga, Khajuri and Gortali ecosystems, India

Occupation	Village ecosystems			
	Patlamba	Rodanga	Khajuri	Gortali
Landless	1	25	-	3
< 1 ha	11	14	15	9
1-2 ha	10	14	32	12
> 2 ha	-	7	14	15
Total	22	60	61	39

Table 8. Distribution of households according to land holding capacity in Majhihalma, Bhaliabhatta, D. Kumbharbadi and Papikhunti ecosystems, India

Occupation	Village ecosystems			
	Majhihalma	Bhaliabhatta	D.Kumbharbadi	Papikhunti
Landless	30	14	6	7
< 1 ha	4	0	9	6
1-2 ha	0	2	8	2
> 2 ha	2	2	3	1
Total	36	18	26	16

Occupational status and household

The houses are constructed in rows facing each other in a commonplace. The house is now AC-sheet/G.I sheet roofed under different schemes, and the use of wild straw has been discontinued. Almost all houses are now pucca for living. The village goddess is worshiped in the middle of the commonplace between the house rows. The animals have separate sheds. Houses are open to the front and back sides without windows or chimneys. A narrow verandah exits on the front side of each house. Separate houses exist for young unmarried boys and girls, known as "Dhangada House." This is a part of their culture. All households of these villages use aluminum and earthen pots. The villagers invariably use Siali and Sal leaf plates and cups. These Tribals use traditional fuel-inefficient mud stoves for cooking.

Socio-economic status

All families of Patlamba are economically backward in comparison to other villages. Traditionally the villagers depend on forests and valleys for their livelihood, but forest degradation has threatened the community for the non-availability of various forest products. Most forests are open and biotic pressure does not allow these to regenerate naturally. As a result, biodiversity has been affected adversely, and many common minor forest products have become rare and threatened. The shifting cultivation area, which is naturally fertile with forest nutrients, provides economic support to the families. The agricultural products obtained are kept for domestic use first, and then the balance is sold in the weekly market. Seasonal products like wild mango, jackfruit, jamun, wild tubers, leafy vegetables, and tamarind are marketed in the weekly market and the nearest Railway Station of Bissam-Cuttack. Truckloads of green jack fruits (for vegetable purposes) are exported to the neighboring states of Chhattisgarh and Andhra Pradesh during January and February. The delicious and large-size jamuns are exported by rail to distant places, which fetch good market value. Siali leaves are collected from the forests and made into leaf plates for marketing. Among the agricultural products, turmeric and ginger are produced commercially, which meets the major family expenses. With the Dongaria Kandha Development Agency (DKDA) initiative, large-scale pineapple cultivation with mango, orange, and litchi has started, providing a good annual income for the family.

Occupation

Shifting cultivation is the major occupation in the uphill areas of "Niyamagiri," whereas the foothill villages practice normal cultivation. The villages like Patlamba, Rodanga, Khajuri, and Gortali have the practice of helping each other in agriculture work in the "Bhuti" system. In this system, all households will depute a worker to work in the field of one family for a day, which is treated as one "Bhuti." The cost of one "Bhuti" is a nominal price, much less than the wage and the benefitted family will pay it to the common village fund. The foothill villages like Majhihalma, Bhaliabata, D.Kumbharbadi and Papikhunti also work as daily wage labor besides cultivation. Though the scheduled tribe community dominates all the villages, the marketing of agricultural products commercially is only conducted by the few members of the scheduled caste community. Collection of minor forest produce from the adjoining villages by the women members and minor children provides off-time engagement in all villages. Collecting firewood (Figure 4.A) for self-use and marketing is a day-to-day practice of the uphill villages (Tables 9 and 10).

Table 9. Occupational status of household in the Uphill Villages, India

Occupation	Villages			
	Patlamba	Rodanga	Khajuri	Gortali
Cultivation	-	-	-	-
Daily wage earner	-	-	-	-
Cultivation + wage earner	22	48	61	39
Animal grazer	-	-	-	-
Carpentry	-	-	-	-
Business	-	12	-	-
Ideal, getting old age pension	-	-	-	-
Total	22	60	61	39

Table 10. Occupational status of household in the foothill villages studied

Occupation	Villages			
	Majhihalma	Bhaliabhatta	D.Kumbharbadi	Papikhunti
Cultivation	-	-	-	-
Daily wage earner	-	-	-	-
Cultivation + wage earner	28	15	26	14
Animal grazer	-	-	-	-
Carpentry	-	-	-	-
Business	8	3	-	2
Ideal, getting old age pension	-	-	-	-
Total	36	18	26	16

Table 11. Animal resources (number of animals) in uphill villages

Animals	Patlamba	Rhodanga	Khajuri	Gortali
Goat	83	51	67	86
Sheep	0	33	0	0
Pig	23	15	168	99
Cattle	4	23	22	25
Buffalo	0	6	0	0
Poultry	90	90	77	173

Table 12. Animal resources (number of animals) of studied foothill villages

Animals	Majhihalma	Bhaliabhatta	D. Kumbharbadi	Papikhunti
Goat	78	13	42	26
Sheep	0	0	0	2
Pig	84	0	23	6
Cattle	39	7	29	34
Buffalo	0	19	0	9
Poultry	140	73	37	99

The details of the livestock population (2010-2011) are given in Tables 11 and 12. We recorded the maximum goat population in Gortali (86) and the minimum in Bhaliabhatta (13). The number of Pigs is highest in Khajuri (168) and lowest in Papikhunti (6), with no pigs in Bhaliabata. The cattle population varies from 4 to 25 in hilly areas inside Niyamagiri Forest and 7 to 39 in bordering villages. Cattle is neither used in agriculture nor milk production in uphill villages, but the foothill villages in the periphery use these animals as drought animals and in the production of milk. It is the source of cow-dung manure for agricultural purposes. Poultry was present in almost all families.

Marketing and marketable surplus products

The Bissam-Cuttack Railway Station and the weekly market of Chatikona are the major marketing area of the villages taken up for the study. The daily consumables are purchased from the weekly market of Chatikona on Wednesday, but the sale of marketable surplus, mainly mango, pineapple, jackfruit, orange, and banana, is done at the railway platform of Bissam-Cuttack Station. The rice and kerosene of the public distribution system are received from Chatikona. Due to the improvement of road communication, the light vehicles reached the village site to purchase jackfruit and pineapple, which are produced in large quantities. The weekly market also provides scope for the sale of minor forest produce like tubers, siali leaf plates, and horticulture products. However, the villages do not have shops to meet their domestic requirement. Therefore, a barter system is still prevailing in the villages, either through vendors or direct transactions.

Physical resource base

The local production systems together form the physical resource base of the villages. These fall into five major sub-systems, i.e., (i) Minor Forest Products, (ii) Valley Agriculture, (iii) Shifting Cultivation, (iv) Home Garden, and (v) Animal Husbandry. The resource bases which are responsible for village ecosystem function are discussed separately under different heads. Forest in and around villages is a major Common Property Resource (CPR) besides the grazing land, road, water sources (*Nala*), etc. The use of the forest for shifting cultivation is an age-old process, an unrecorded right that is socially accepted by the village community. The forest area, excluding the shifting cultivation sites, forms the CPR for all households of the Schedule Tribe category. The Schedule Caste households, wherever present, are not allowed to occupy land in the Government Forest area. A few Schedule Caste households have a Revenue Record of Right but do not go for cultivation. Instead, they are involved in the marketing business of agricultural products produced by the Schedule Tribe households. Since the forest area is vast and the population is very much restricted to small pockets, there is no conflict in the collection of Minor Forest Produce (MFP) (Table 13).

Besides shifting cultivation areas, every household has developed orchards in lower hill areas by planting mango, orange, litchi, banana, etc., which is in forest area and excluded from CPR. Ginger and turmeric are valuable cash crops and contribute to the family's major income. The forest adjoining villages are degraded miscellaneous species in composition and the soil erosion is prominent due to hilly topography. Lacking fertile soil and humus has led to poor regeneration capacity and low productivity. Accordingly, the quality, quantity, and variety of MFP available are reduced yearly. The practice of shifting cultivation by the Dongaria Tribe has also affected the vegetation cover and surface soil. Despite the reduced availability of Different Forests Produce (CPR), the sharing habit is strongly accepted by society without any internal dispute. The practice of agriculture and collecting Firewood and MFP (bamboo, siali leaves, wild tubers, mango, jackfruit, and tamarind) control the village's household economy. An in-depth study of the CPR system is essential for understanding the function of a tribal village ecosystem.

Participatory rural appraisal

All households were allowed to participate in the PRA exercise to express their views on the resource base of the village, its present use, and proposed improvement for the community. The information on the natural resources like forests, water sources, and land resources was recorded to prepare the village-wise information sheet for the present study. During the study, the villagers were interviewed about the status of CPR. Everybody was allowed to give his impression about the status. The persons were also interviewed in separate groups to know the priority of different forest products available to them in their village site. As a result, the forest area is given priority among different CPRs like grazing land, water bodies, roads, etc.

Community forest

The uphill and foothill villages depend on the forest for firewood, bamboo, small timber, etc. The uphill villagers are involved in large-scale shifting cultivation, whereas the foothill villagers depend on normal agriculture practices. The uphill villagers inhabit small pockets with forest cover

on all sides, whereas the forest has receded to distant places from the foothill villages. The forest in both areas has been degraded due to over-exploitation during the last 40 years, which the elderly persons from the community informed. The forest was dense with wildlife populations, even with the highest predatory animal (tigers). The increasing demand for timber, house construction, and the poor economic condition of local inhabitants are the important reasons for felling trees. The fruit-bearing trees like mahua, mango, tamarind, jamun, and char are protected besides *Caryota* palm, which provides *Caryota* sap.

In 1988 the Government of Odisha assigned Forest Protection Activity to the adjoining village community by forming the Village Forest Protection Committee (VFPC). The foothill villagers were involved in forest protection, as they have limited resources (forest area), but the uphill villagers did not pay attention as they have plenty of forest area. Gradually over the years, the Government policy changed to facilitate several benefits to the village community through Joint Forest Management Committee (JFMC) with a resolution in 1993. This resolution has also undergone various amendments during 2008, 2011, and 2015 to meet the changing requirement of the Forest and Community.

Annual collection of Minor Forest Products (MFP)

The collection of MFP is a traditional practice of all villages in a forest area. Besides the adult male and female members, children of all age groups participate in different activities of the collection process as per their ability. All products collected from forests, excluding timber, firewood, and bamboo, are treated as MFP (Figures 4.A-I). After the Government Resolution of the year 2000, the collection right of MFP is given to the public, which can be collected by a registered agent of Gram Panchayat with the market price fixed in the Panchayat Samiti. For the source of MFP, the forest and village community are closely associated over generations. MFP meets the daily requirement of many commodities necessary for the day-to-day life of Tribals. The surplus MFP is exported from the villages. The MFP collected by the tribal people of the villages during 2010-2011 is given in Tables 14, 15 and 16.

Forest and local products

The mahua tree (*Madhuca latifoila*) is an economic species for the forest fringe villagers and is mostly worshiped in various ways. The mahua (or mahula in local dialects) flowers are collected during March and April for domestic consumption and commercial use in preparing country liquor. Mahula trees provide oil seeds collected during May and June for the cooking and burning purposes of the tribal communities. Mahula trees are well distributed in foothill villages and very rarely seen in uphill areas. The tamarind (*Tamarindus indicus*) trees grow in the wild and are protected by villagers for the collection of tamarind. These trees are very few and are the villagers' common property. Most of the quantity collected is sold in the weekly market at Chatikona to meet the market expenses for domestic purchases of the tribal people. Siali (*Bauhinia valichii*) leaves are collected by women members and stitched to plates (khali) and cups (dana) for selling in the weekly market. The collection is taken up during August and September, which is an idle period for agricultural activities. Bamboo is a common agricultural material for fencing and roofing work in the village area. A limited number of people takes up a collection of bamboo from the forest for domestic and marketing purpose. The young shoots of bamboo (karadi) are collected for self-use and export purposes during the rainy season. This is used as vegetables in many parts of the district. The alcohol produced from *Caryota* palm (salapa) is collected by a limited number of persons from adult plants of *Caryota* palm. It is collected during winter and summer seasons and sold in the village area. *Caryota* palm is distributed in a limited village area; thus, the production of *Caryota* sap is limited. This sap is a nutritious food for the tribal people. This sap extracted during the day is generally consumed on the same day. During the peak period of sap production, Tribals of the nearby villages shared the sap by coming over to the place of production. Although the sap is generally consumed three times a day, they took it when required, as the sap production continued up to the end of the season.

Table 13. Production/ collection of Minor Forest Produce (MFP) in the villages (Mg village^{-1} yr^{-1})

Item	P	R	K	G	M	B	D	H
Bamboo	42.4	34.6	30.8	17.3	18.3	8.5	13.8	7.5
Broom grass	0.19	0.38	0.45	0.4	0.3	0.25	0.2	0.15
Mahua flowers	0.09	-	-	-	-	-	-	-
Sap of Caryota	0.26	4	5.05	3.3	-	-	-	-
Leafy Vegetables	0.51	0.77	0.75	0.56	0.21	0.12	0.11	0.15
Siali Leaf	0	0.161	0.176	0.85	-	-	-	-
Tamarind	0.155	0.35	0.32	0.25	0.05	0.03	0.05	0.03
Miscellaneous fruits	0.153	-	-	-	-	-	-	-
Wild tubers	0.925	2.385	2.705	1.56	-	-	-	-
mango	4.48	48.3	56.92	26.75	-	-	-	-
Small timber/ Pole	33.02	18.7	16.75	11.7	10.05	5.65	6.4	5
Amla	0.22	-	-	-	-	-	-	-
Fire wood	253.2	419	426	226.5	259	106.5	197	101.5

Note: Average weight of bamboo taken as 20 kg each; Siali leaf plate bundle (100nos) taken as 350gm average; Weight of each pole taken as 10 kg

Figure 4. A. Firewood collection from forest, B. Marketing of pineapple, C. Young shoots of bamboo (Karadi), D. *Caryota* palm, E. Jackfruit at Niyamgiri, India, F. Hill broom, G. Jamun fruit, H. Collection of wild mango, I. Siali leaf pots

The villagers use the thatch grass to thatch their huts for themselves and domestic animals. Gradually over years, different projects have been taken up in the areas, especially after Dongoria Kandha Development Agency (DKDA) was established in 1978 to provide support for the livelihood of these Particularly Vulnerable Tribe Groups (PVTG). As a result, the roof structure changed from traditional thatched roofs to G.I. or A.C. sheet roofs. Thus, the use of thatch grass to make roofs has been abandoned and is rarely seen in uphill villages, only for domestic animal huts, etc. Broom grass naturally occurs in moist areas, especially the Nala sides, which flowers during winter, and the sticks (inflorescence stalks) are collected during January and February for use as broomsticks. Therefore, it is very common in uphill areas and rarely found in foothill areas. The annual collection is made to usable broom sizes and sold in the weekly market. Domestic consumption is very little. The average village-wise collection is 355 kg in the uphill areas and 225 kg in the foothill villages (Tables 15 and 16).

Wild mango is collected from the green stage to mature condition for marketing in the weekly market or Railway station area. It provides jobs for about three months. The collection of jackfruits in the early stage for vegetable purposes provides a large-scale market to the community. It is exported by rail and road, providing good annual income to the villagers of uphill areas. The jamun (*Eugenia jambolana*) fruit is unique in this area for its attractive size and taste. It is marketed to the outside areas of different States, providing a good economy to the locality. Among other fruits, tamarind, kendu, bhalia, khajur, etc., are commonly collected for self-use and marketing. The common leafy vegetables are *Bauhinia*, *Amaranthus*, and *Marsilea*, with many more varieties collected in different seasons. *Bauhinia* is the most frequently used leafy vegetable, collected to 3180 kg annually by all the villagers. Other Minor Forest Products include Myrobalans, wild tubers, etc., which are collected in small quantities, having less impact on the rural economy. Edible mushrooms and *Bauhinia* seeds are also collected from the forests for domestic use.

Table 14. Production, consumption and export of Minor Forest Products (MFP) in Village Patlamba, Rodangaand Khajuri, India

Minor Forest Products	Patlamba			Rodanga			Khajuri		
	Collection	Consumption	Export	Collection	Consumption	Export	Collection	Consumption	Export
Bamboo (*Dendrocalamus strictus*)	42.4	2.2	40.2	34.6	30.4	4.2	30.8	30.0	0.8
Broom grass	0.19	0.04	0.150	0.38	0.060	0.320	0.45	0.070	0.380
Mahua flower	0.09	0.03	0.060	-	-	-	-	-	-
Sap of caryota palm	0.26	0.00	0.180	4.00	0.390	3.610	5.05	1.180	3.870
Leafy vegetables	0.51	0.26	0.250	0.77	0.400	0.370	0.75	0.250	0.500
Siali leaf	-	-	-	0.161	-	0.161	0.176	-	0.176
Tamarind	0.155	0.04	0.115	0.35	0.050	0.300	0.32	0.060	0.260
Misc. fruits	0.153	0.153	-	-	-	-	-	-	-
Wild tubers	0.925	0.925	-	2.385	2.385	-	2.705	2.705	-
Mango (wild)	4.48	0.42	4.06	48.3	7.180	41.12	56.92	9.96	46.96
Small timber/poles	33.02	1.78	31.24	1.870	1.590	0.280	1.675	1.675	-
Amla	0.220	-	0.220	-	-	-	-	-	-
Wild date	-	-	-	-	-	-	-	-	-
Firewood	253.2	89.6	163.6	419	186.35	232.65	426	346	80
Total	335.603	95.528	240.075	511.816	228.805	283.011	524.846	391.90	133.146

Note: Average weight of bamboo taken as 20 kg each; Siali leaf plate bundle (100nos) taken as 350gm average; Weight of each pole taken as 10 kg

Table 15. Production, consumption and export of Minor Forest Products (MFP) in Village Gortali, Majhihalma and Bhaliabhatta, India

Minor Forest Products	Gortali			Majhihalma			Bhaliabhatta		
	Collection	Consumption	Export	Collection	Consumption	Export	Collection	Consumption	Export
Bamboo	17.3	17.3	-	18.3	17.5	0.8	8.5	8.5	-
Broom grass	0.400	0.060	0.340	0.300	0.060	0.240	0.250	0.050	0.200
Mahua flower)	-	-	-	-	-	-	-	-	-
Sap of caryota palm	3.300	0.740	2.560	-	-	-	-	-	-
Leafy Vegetables	0.560	0.260	0.300	0.210	0.050	0.160	0.120	0.030	0.090
Siali leaf (No of plates)	0.85	-	0.85	-	-	-	-	-	-
Tamarind	0.250	0.050	0.200	0.050	0.050	-	0.030	0.030	-
Misc fruits	-	-	-	-	-	-	-	-	-
Wild tubers	1.560	1.560	-	-	-	-	-	-	-
Mango (wild)	26.750	4.250	22.50	-	-	-	-	-	-
Small timber/poles	1.170	1.170	-	1.005	1.005	0	0.565	0.565	-
Amla	-	-	-	-	-	-	-	-	-
Wild date	-	-	-	-	-	-	-	-	-
Firewood	226.50	177.50	49.00	259.00	208.50	50.50	106.50	83.50	23.00
Total	278.64	202.89	75.75	278.86	227.165	51.70	115.96	92.675	23.29

Note: Average weight of bamboo taken as 20 kg each; Siali leaf plate bundle (100nos) taken as 350gm average, Weight of each pole taken as 10 kg

Table 16. Production, consumption and export of Minor Forest Products (MFP) in the village D. Kumbharbadi and Papikhunti, India

Minor Forest Products	D. Kumbharbadi			Papikhunti		
	Collection	Consumption	Export	Collection	Consumption	Export
Bamboo	13.8	13.0	0.8	7.5	7.5	-
Broom grass	0.200	0.050	0.150	0.150	0.050	0.100
Mahua flower	-	-	-	-	-	-
Sap of caryota palm	-	-	-	-	-	-
Leafy vegetables	0.110	0.110	-	0.150	0.040	0.110
Siali leaf	-	-	-	-	-	-
Tamarind	0.050	0.050	-	0.030	0.030	-
Misc. fruits	-	-	-	-	-	-
Wild tubers	-	-	-	-	-	-
Mango (wild)	-	-	-	-	-	-
Small timber/poles	0.640	0.640	-	0.500	0.500	-
Amla	-	-	-	-	-	-
Wild date	0.095	0.045	0.050	-	-	-
Firewood	197.000	158.500	38.500	101.500	81.500	20.000
Total	211.895	172.395	39.50	109.83	89.62	20.21

Note: Average weight of bamboo taken as 20 kg each; siali leaf plate bundle (100nos) taken as 350gm average, weight of each pole taken as 10 kg

The sustainability issue of the Niyamgiri ecosystem has been in public debate for a long time due to proposed policies to start mining activities in the region. Niyamgiri hills in Rayagada district attracted much research for Dongria Kandha "Particularly Vulnerable Tribal Groups" (PVTG) for their socio-economic and cultural traditions. The villages are surrounded by hilly forests of high altitudes, creating a micro-climatic effect in the locality. The economy is dependent on agriculture, MFP collections, and to some extent, animal husbandry. The village ecosystem's major activities were directly or indirectly linked to the forest ecosystem directly or indirectly. Thus, the forest is the rearing base of the tribal, and the tribal, in return, pays tribute to the trees and mother earth in the traditional worshiping process at the beginning of the cultivation, during crop cultivation, and after harvest.

Structure of village ecosystem

Tribal communities prefer natural forest pockets to meet their basic needs of food and shelter. Commonly known as "ecosystem people" (Dasmann 1988), they depend on natural resources and, unlike urban people, they do not expect beyond their reach. Government schemes have improved communication and education facilities over the years. Dongaria Kandha Developing Agency (DKDA) also helped to improve the horticulture activity by providing seedlings, planting techniques, and financial assistance. The traditional thatched roof has been changed to A.C. Sheet/G.I Sheet roofs, and in almost all villages, "Indira awas" houses have been provided to the families. The village-wise human population varies from 76 (Papikhunti) to 312 (Khajuri), with an average family size of 3.8 to 5.1. All adult members of the family work in the field except older persons of age above 70. The male-female ratio varies from 1:1.04 (Bhaliabhatta) to 1:1.59 (Patlamba) except in Papikhunti, where the male population was higher, i.e., 1:0.68. In the district-level male-female ratio, Rayagada recorded 1:1.028 in the 2001 census and 1:1.051 in the 2011 census. The literacy rate was found to be lowest at Patlamba (4.8%) and highest at D. Kumbharbadi (72%), which is comparable to the state literacy rate of 72.9% (Census 2011). The literacy rate of Rayagada District in 2011 was recorded as 49.8%. The school-going children are deviated to agriculture and animal husbandry work, reducing the literacy rate. The low literacy rate was due to the traditional practice of domestic work and the lack of infrastructure for schooling. The villagers had no communication facility for the students to attend school in the hilly forest areas. The D. Kumbharabadi, the foothill village and nearer to urban places with schooling facilities, has the highest literacy rate. But now the education facility has improved and girl students also are motivated by the Government to attend school. Patlamba village has the lowest family size of 3.8, which was greater than the family size of 3.6 of tribal villages of the Gajam District of Odisha (Nayak et al. 1993). The highest family size, i.e., 5.1 in village Khajuri is more than that of coastal villages, 4.7 (Sahoo and Mishra 1992). Lack of education and awareness has affected the socio-economic status adversely, and the use of alcohol has reduced the working ability of the population. Almost all adults in the uphill villages are illiterate. Due to the improvement in schooling facilities and motivation, the children are attending schools. Recently, DKDA has focused on educating the girl students by providing residential school facilities.

The practice of agriculture under Podu cultivation, mid-hill orchards, home gardens, and valley cultivations involved men and women for about 8-9 months a year. The collection of minor forest products provides work for 3-4 months a year. Firewood collection is one of the important components of a forest ecosystem. The per capita agriculture land varies from 0.117 ha (Patlamba) to 0.329 (D. Kumbharabadi). In uphill villages, podu cultivation contributes more significantly than all the other three categories. In foothill villages, the podu cultivation area was slightly higher over valley cultivation except in Bhaliabhatta, where the valley cultivation (4.574 ha) was

more than the podu cultivation area (4.129 ha). The average per capita cultivated area (0.117 ha) in Patlamba was lower than in Bhogibunda (0.18 ha) village (Nayak et al. 1993) and the average value (0.26 ha) for India (Ravelle 1976).

Agriculture sub-system

The perennial streams are used in valley cultivation, especially the paddy with good soil depth. The other three categories of agriculture practices, i.e., podu cultivation, mid-hill orchard and home garden, are under rain-fed conditions. The dry deciduous tropical forest ecosystem surrounds the habitation and helps in the perennial flow of streams. The four uphill villages focus on podu cultivation and mid-hill orchard. Podu cultivation is done for minor millets like finger millet, common millet, pearl millet, and barnyard millet, with pulses like redgram and jhudanga (*Vigna* sp.). The mid-hill orchard provides orange, pineapple, jackfruit, and mango fruits for sale, with cash crops of turmeric and ginger. Podu cultivation is a traditional practice known as shifting cultivation, as the tribal people used to shift to a new place periodically and then return. This land use pattern enhances soil erosion as the seedlings and all growths are cut and burned before seeding. Thus, it is not an eco-friendly practice and gradually reduces forest cover. Podu cultivation reduces soil fertility, which farmers leave for several years to allow it to regain its fertility by the natural process of soil cover growing out of existing rootstock and weeds. In podu cultivation, all activities are done manually and no tilling is possible by draught animals. The podu area is normally near the village boundary at high hill altitudes. The cultivation of red gram (kandula) increases soil fertility by fixing atmospheric nitrogen. Podu cultivation gradually reduces the area and quality of the forest for which it has been suggested for artificial regeneration of tree crops (Watson 1983; Akachukwa 1985; Ramakrishnan 1985). Since the requirement of the Tribal community is multiple products, food production through site-specific agroforestry models can meet the day-to-day family requirement.

In tribal villages, where the geography is undulating in nature, agriculture depends on human energy and, to some extent, draught animals. In developing countries, agriculture operations mainly depend on human energy and animal energy (Hall et al. 1982). The uphill villages depend entirely on human labor, whereas the foothill villages depend on human and animal energy. Bullock is preferred over buffalos for agriculture operations. Fertilizers, pesticides, irrigation, and organic manure are not used in podu cultivation. Podu cultivation is practiced in high hill areas, mostly inside forest boundaries. The Asian Rural Life Foundation Philippines has developed different models for these areas with a common name of SALT (Slopping Agriculture Land Technology), which is suitable for the geographic and adaptive conditions and able to meet the socio-economic need of the community. The SALT-2 model was tagged with livestock and SALT-3 refers to an integrated system of Agroforestry. Fixation of atmospheric Nitrogen can improve the soil status, leading to better crops. The choice of species for different components is more important for a successful model.

The production of minor millet is prominent in uphill villages. Four categories of millets, different pulses, and oil seeds were grown on the same plot in Podu cultivation. The productivity of finger millet grain was 701 kg ha^{-1} in Patlamba, 757 kg ha^{-1} in Rodango, 927.87 in kg ha^{-1} Khajuri and 961.1 kg ha^{-1} in Gortali, where millet was widely used. All the above value of productivity is higher than the average district productivity of 656 kg ha^{-1} (District Statistical Hand Book Raygada 2011). The cause of higher productivity may be attributed to better soil fertility and cultural operations. Among the foothill villages, higher productivity was recorded for Majhihalma (794.10 kg ha^{-1}) and Bhaliabhatta (660.8 kg ha^{-1}) whereas D. Kumbharbadi (562.72 kg ha^{-1}) and Papikhunti (559.15 kg ha^{-1}) have productivity at par with Rayagada district record of 656 kg ha^{-1}. Lower productivity in foothill villages may be due to eroded soil cover with lower fertility. On the other hand, the productivity of finger millet in other settled village ecosystems, such as Ungra (1.23 t ha^{-1}) and Bhabinarayanpur (1.08 t ha^{-1}), is much higher (Nisanka and Mishra 1990).

Barnyard millet is another important product for food in uphill villages. All four uphill villages and Papikhunti of foothill village take up its cultivation with production value ranging from 633 kg ha^{-1} (Patlamba) to 803.71 kg ha^{-1} (Rodanga). Well-drained fertile soil with the effect of slash burning process before sowing of seed provides good growth and more productivity. Though comparison records are not available, it can be considered in line with finger millet. Pearl millet is a mixed cropping system that has low share and productivity, which varies from 56.4 kg ha^{-1} (Rodanga) to 110.5 kg ha^{-1} (Patlamba). It is locally known as "Ghantia" and no records are available for comparison. Similarly, another kind of millet, commonly millet locally known as "kangu," is partially added to the podu cultivation mixed cropping. It has a productivity value ranging from 87.82 kg ha^{-1} (Khajuri) to 424.45 kg ha^{-1} in Patlamba. The normal practice of planting maize is in rows at certain intervals. Only the Village Papikhunti had the practice of planting in blocks. The productivity in these villages was 220 kg ha^{-1} in Patlamba, 340 kg ha^{-1} in Rodanga, 203.5 kg ha^{-1} in Khajuri, 184.9 kg ha^{-1} in Gortali, 193.3 kg ha^{-1} in Majhihalma, 190.2 kg ha^{-1} in Bhaliabhatta, 184.21 kg ha^{-1} in D. Kumbharbadi. The productivity of maize in Papikhunti was 1173.28 kg ha^{-1}, which is comparable to the district record of Rayagada, i.e., 1112 kg ha^{-1} in 2010-2011 (District Statistical Hand Book Raygada 2011).

The large-scale cultivation of redgram, jhudanga, and kating in podu cultivation provides a good economic return to the tribal community. Due to the good market value, most pulses were sold, keeping small quantities for seed and annual domestic use. The redgram grain productivity was 826 kg ha^{-1} in Patlamba, 995 kg ha^{-1} in Rodanga, 1072 kg ha^{-1} in Khajuri, 1236 kg ha^{-1} in Gortali, 702 kg ha^{-1} in Majhihalma, 844 kg ha^{-1} in Bhaliabhatta, 432 kg ha^{-1} in D. Kumbharbadi and 1537 kg ha^{-1} in Papikhunti. The productivity, in general, is higher in uphill villages due to

their soil condition and traditional intensive care. Among foothill villages, Papikhunti villagers concentrate on Podu cultivation as they do not have a paddy cultivation area and their suitable land with good soil depth and soil fertility as observed in the field. Among other pulses, jhudanga and kating cultivation also provide a sizeable cash economy to these tribal villages. The productivity of jhudanga varies from 269 kg ha^{-1} (Patlamba) to 1350 kg ha^{-1} in Gortali village. The productivity of kating varies from 331 kg ha^{-1} (Rodanga) to 447 kg ha^{-1} in Gortali, and it is not cultivated in foothill villages.

Mid-hill orchards are two tiers cropping patterns with fruit trees of mango, orange, jackfruit, etc., with pineapple, turmeric, and ginger as under crops. Almost all crops are cash crops. The harvested crops are sold in the fields or taken to the weekly market. Normally, the scheduled cast communities do the trading, who do not go for agriculture operations. The major harvest profit goes to the trader instead of the real farmers, who invest a lot of physical labor in adverse conditions. The farmers are compelled to dispose of the products soon after the harvest due to a lack of storage facilities. Post-harvest management of crops or value addition can change the situation in favor of the farmers. Home gardening involves the production of vegetables, maize, etc., which is practiced and consumed inside the village in uphill villages and rarely some quantity was sold. But in foothill villages, surplus vegetables are sold in the local market. Papikhunti village recorded the highest area under the home garden. The village is nearer to the market area and thus marketing was easier. Paddy cultivation was taken up in one village (Rodanga) out of four uphill villages under study. The productivity of paddy was 2.424 t $ha^{-1}yr^{-1}$. The productivity is lower than the productivity for the lower elevation of Meghalaya, 3.71 t $ha^{-1}yr^{-1}$ (Toky and Ramakrishnan 1981). Three villages in the foothill area take up paddy cultivation, except for the village of Papikhunti. The Paddy productivity was 3.11 t $ha^{-1}yr^{-1}$ in Majhihalma, 2.796 t $ha^{-1}yr^{-1}$ in Bhaliabhatta and 3.192 t $ha^{-1}yr^{-1}$ in D. Kumbharbadi. The highest productivity of D. Kumbharbadi is less than 4.70 t $ha^{-1}yr^{-1}$ from the plain lands of Odisha (Nisanka and Misra 1990). The lower productivity in uphill and foothill villages can be attributed to the subsistence farming system followed by the tribal people. They depend on soil's natural fertility without adding any organic or inorganic manure. The seed input is also an age-old local variety and the cultural operations are not followed properly.

Animal husbandry sub-system

Animal husbandry is a practice only by tradition. The family head has not given the rearing importance. The old woman or young boys and girls take the herd to the forest for feeding. The fodder availability changes with a monsoon. The uphill villages neither go for milk collection nor use draught power. Animals and poultry birds are used for worship offerings in different functions. In other hilly areas of India, where land availability for green fodder is more, people invest in livestock though agriculture land availability is limited (Moench 1989). The ratio of the human population to livestock population varies from 1:0.43 (Bhaliabhatta) to 1:1.34 (Majhihalma), which indicates a poor population compared to other tribal villages of the State. Nisanka and Misra (1990) reported the average human and livestock animal ratio as 1:0.96 in an agricultural village. Four villages were found to be above average value (Patlamba, Gortali, Majhihalma, and Papikhunti) and the other four villages (Rodanga, Khajuri, Bhaliabhatta, D. Kumbharbadi) were below it. The human and livestock ratio has been reported by Sukla and Pandey (1993) for tribal villages of Madhya Pradesh as 1:1.05, whereas Nayak et al. (1993) reported the ratio as 1:0.67 for tribal villages in Odisha. The scrub cattle population carelessly moves into forest areas and takes shelter in villages. The main economy may be the collection of dung during shelter time which is used in home gardens and valley cultivation. However, foothill villages are better animal husbandry managers, and few families take care of cows and buffalo and collect milk for sale. Dung is collected and taken to valley cultivation after decomposition. In all villages, there is scope to improve animal husbandry. Eastern Ghats' dry tropical areas are comparable to humid tropical areas where animal husbandry is a low-cost sub-system (Payne 1985). This is because of the easy availability of natural resources in the humid tropics (Gomez-Pompa et al. 1972) and lesser population pressure as in the Northeastern hill region (Ramakrishnan 1985). Some have adopted swine rearing for its low-cost management and rapid population increase, leading to a better return.

Forest products

Minor Forest Product (MFP) has developed a socio-economic link between forest and village ecosystems. The adaptations for collecting MFP and the poverty of villages have led to easy access to forest natural resources. Besides the highly valuable intangible benefit of a clean environment, the forest provides food, fuel, and fodder for the village ecosystem. The shifting cultivation lands on hill slopes with little soil cover meet the daily need of the family. This process of shifting cultivation gradually reduces the soil depth and soil quality which affects productivity.

Besides MFP, the villagers collect bamboo, fuel wood and miscellaneous poles for use in the village and sale in the local market to meet family expenses. Few people in the uphill villages have the routine practice of collecting and selling firewood and bamboo in the market. Aged persons from the local forest area the collection of firewood. Bamboo is collected from distant places because it is not available in the nearby areas for which young people do the work. The maximum number of bamboo collected by Patlamba was 2120 stems in a year, followed by Rodanga (1730), Khajuri (1500) and Gortali (865) in uphill villages. Among the foothill villages, a maximum number of bamboo was collected by Majhihalma (915), followed by D. Kumbharbadi (690), Bhaliyabhatta (425), and Papikhunti (375). Majhihalma villagers have more vegetable areas and use more bamboo for support etc.

Wild mango collection and sale at Bissam Cuttack Railway Station provides about three-month summer engagement to the uphill villagers. Young and old persons move along the Nala sides, and the collection starts from the green stage of mango until full ripening. The only investment is human labor and the green mango usually sells at Rs. 2/- to Rs. 3/- per kg. The ripened mango is sold at the rate of Rs. 8-10/- kg for good quality variety. The highest quantity of mango collected in village Khajuri (56.92 Mg), which provides economic support in the summer month to the uphill villagers. Dry firewood is taken to the local market for sale. One head load of about 30-40 kg fetches a market value of Rs. 80/- to Rs. 120/- depending on the season. This forms a major share of the village economy on a sustainable basis. The highest quantity is collected in the village Majhihalma (259 Mg), which has easy access to the good forest. The consumption-to-sale ratio varies from 1:0.24 to 1:1.82. Patlamba and Rhodango have a 1:1.82 and 1:1.24, respectively, far more than in other villages where the consumption-to-sale ratio varies between 1:0.23 to 1:0.27. The villages closer to the deep forest area uphill, i.e., Khajuri, Rhodango, and Gortaoli go for siali leaf collection during the rainy season when the agriculture work is less intense. Gradually over the years, the availability of siali leaves has been reduced and the villagers must go far away to get a head load. The collected leaves are stitched to plates and air-dried in the shade during the rainy season. The leaf plates are bundled into 100 number packets for sale. The average weight of a packet varies from 350-400gm. Since the availability of siali leaves has been affected due to forest degradation, the forest around the habitations can be taken up for re-stocking, which will ameliorate the environment besides providing sustainable natural resources. This woody climber can cover the bare rocks where other vegetation can rarely establish. Earlier it was a good revenue source for the Government, while Tribal Development Co-operative Corporation (TDCC) would arrange marketing facilities. The Dongoria Kandha Development Agency (DKDA) can take up the work as it is its focus area. It will be a visible project within five years.

The tribal communities worship the mahua tree for its benefits from the fruit and flower due to its high glucose content, which is used in preparing different food items and is commonly consumed as country liquor. Here, the tree distribution is very much limited in the foothill area. Patlamba villagers go for collection in the uphill villages as few trees are available but in other village localities, the mahua tree is not available. To date, no attempt has been made for plantation on a large scale. It has the potential to provide a high level of sustainable income to tribal families or even elsewhere in the plains. The productivity of the tree varies greatly with age, i.e., crown spread. The Mahua flower is collected after clearing the base, i.e., dried leaves are removed or burnt. The beautifully scented flower attracts insects, honeybees, cattle, and the human population. The average flower production observed per plant is 10 to 20 kg, comparable to the available data, such as 16.5 kg and 21.5 kg sun-dried flowers in two years, 1968, 1969 for the Umerkote forest of Koraput (undivided) district of Odisha. Prasad (1992) observed a yield range for 7 to 145 g tree^{-1} flowers at SFRI Jabalpur. Dwivedi (1989) estimated the yield of mahua flowers from 10-140 kg tree^{-1} year^{-1} in 10-60-year-old trees. The lower flower yield may be attributed to the unhealthy growth of a tree. The plants are situated mostly on rocky hillocks and are widely scattered. Though authentic records of production are rare, the villager has the confidence to manage family expenses if 25-30 numbers of adult trees are available with a family.

The social tradition of the village community to worship the mahua tree gives sufficient protection from its cutting. People will never feel a mahua tree. A large-scale commercial plantation, with beneficiaries' involvement, will definitely provide sustainable income. The use of the Mahua flower in preparation of country liquor has been a common practice for a long. The country liquor, locally known as "mahuli," is used by most Tribals. The alcohol content of "mother liquor" is 4.4%, while that of spirit (distilled) is 19.58% (v/v) (Prasad 1992). The habit of the rural community of country liquor often leads to unsocial addiction and indebtedness to the businessman. The tamarind tree is also spread on hill slopes towards the top and protected by local inhabitants for its fruit. Fruit is collected in summer and the fruit coat is removed. It is preserved for the whole year in different pickles, etc. The area under study has a poor distribution of tamarind trees. It can be increased to a suitable number so that m of tamarind is collected and the processed tamarind pulp can be expo out. The commercial use of seed is also possible through the extraction of starch. In the forest area, sap from *Caryota* palm trees is collected for local use. It is commonly known as "salap." The villages having *Caryota* palm may collect the sap or lease it out to a village for the collection of sap. The collection time is thrice a day, i.e., early morning, midday, and evening, which starts in winter and continues through summer until the flow of sap stops. Local villages gather at a commonplace and consume the sap. The excess collection is sold to other villagers. The five-liter container costs Rs. 100 to Rs. 120 each. The collection of sap depends on the tree's age and the quantity of sap collection, which varies from 4-20 liters, which is well within the range (4.5 to 23 liters) reported for other areas (CSIR 1992). The *Caryota* sap is a very nutritious drink before it is fermented. It is rich in sugar and vitamins. Fresh sap contains sucrose up to 13.6% and a trace of reducing sugar, whereas fermented sap contains reduced sugar 1%, alcohol 3.0 to 4.5% and acetic acid 0.3% (CSIR 1992). After fermentation, it becomes alcohol. The fresh sap can also be used to prepare palm gur or jaggery, produced in other parts of India. In Kerala, jaggery is produced in villages and cooperative societies, as reported in the Wealth of India 1992 (CSIR 1992). Besides sap production, *Caryota* palm pith and stem wood produce sago and leaves for domestic purposes. The distribution of *Caryota* palm is in rocky places of a forest. The unmanaged collection of sap and cutting of leaves has led to the destruction of palms. This beautiful palm increases the scenic value of the forest on hill slopes. A policy is needed for artificial regeneration on a large scale by utilizing open forests so that commercial use for any

economic value will be possible. Sal is the dominant species of Eastern Ghats forests with an association like Bija, Sissoo, Asan, Dhaura, etc. The priority of the tribal community is sal. The seedling is used for a toothbrush, saplings are used for fencing and housing, poles of sal are cut for rural houses and the trees are cut for timber values. Hence sal is a target species of Tribals, though they traditionally worship the sal tree. The firewood and sal poles are cut regularly to meet the domestic need and cash income. This economic process is not economically acceptable. Gradually, the situation will change with the use of electricity and the LPG cooking process.

The growing forest can be used alternatively for any community benefit. The input-output ratio of MFP collection varies from 1:38.47 (Gortali) to 1:50.46 (Bhaliyabhatta), much higher than the agriculture production sub-system. In the agriculture sub-system, the input-output ratio varies from 1:11.63 (Rhodango) to 1:23.32 (Bhalyabhatta. The MFP collection is no investment practice for the low-income group, dominating the tribal pockets. The female workers and children mass mainly attend it. Hence in the guise of family sustenance, the education of boys and girls is neglected. The tribal community is intimately associated with both the agroecosystem and forest ecosystem. The valley cultivation is taken up on Nala (Stream) side with maize and paddy, which is prominent in foothill villages. Other cultivation practices, i.e., podu cultivation, mid-hill orchard and a home garden, are taken up in forest areas, the food base of uphill villages. Forest is also used for grazing animals.

Consumption pattern

Agriculture is the main food source for the villages. Per capita consumption of food items indicates inter-village variations in the use of cereals and legumes (Table 17). The quantity of use of cereals varies from 247.69 gm cap^{-1} day^{-1} (Khajuri) to 392.39 gm cap^{-1} day^{-1} (Rodanga) in uphill villages. The value is much higher in foothill villages, which varies from 213.25 gm cap^{-1} day^{-1} (Papikhunti) to 791.80 gm cap^{-1} day^{-1} (D. Kumbharbadi). The average per capita cereal consumption is higher in foothill villages and lower in uphill villages compared to the reported value of 525 gm cap^{-1} day^{-1} for tribal village Bhogibandha (Nayak et al. 1993) and the coastal village 585 gm cap^{-1} day^{-1} of Odisha (Sahoo 1993). Generally, the value is lower than that of the agricultural villages of Bhahinarayanpur (Nisanka and Misra 1990).

The highest per capita food consumption in village Khajuri (791.80 gm cap^{-1} day^{-1}) is due to higher paddy cultivation in the valley and easy access to urban facilities near the market. The other village, Papikhunti, concentrates on vegetable production and there is no scope for paddy cultivation in the valley Nala (stream) sides. Access to the Public Distribution System (PDS) is better in these two villages than in other villages. Food consumption in all villages is less than the average requirement, as suggested by the national expert group of the ICMR (Gopalan et al. 1982). The highest value of Khajuri village is at par with the value reported for other villages in Odisha (Sahoo 1993) but higher than that reported for a tribal village on the Mahendragiri foothills (Nayak et al. 1993). The uphill villages depend on the variety of minor millets produced in podu areas. In general, all villages suffer malnutrition due to insufficient food consumption. Illiteracy and addiction of tribal to low-cost liquor create health problems responsible for the economy's deterioration. The tribal community is associated with using country liquor in various rituals. Sometimes it spreads to full-time consumption of liquor, leaving the day-to-day family work. This is an adverse effect on society. The use of sap in *Caryota* has been recorded, but the per capita use could not be estimated as several users vary daily and the places of use are not fixed. But the collection quantity is accessed based on several trees and sample measurements.

The villagers use a traditional cooking system with "challah" where firewood (biomass) is used due to easy availability. Kerosene is used for lighting. Firewood collection by cutting immature trees is responsible for the deterioration of forest crops. The per capita per day consumption of firewood varies from 1.855 kg (Rodanga) to 3.080 kg (Khajuri) in uphill villages and 2.577 kg per day (Bhaliabhatta) to 4.402 kg day-1 (D. Kumbharbadi) in foothill villages. The average per day consumption is lower in uphill villages than in foothill villages. The annual per capita fuel wood consumption varies from 0.667 Mg (Rodanga) to 1.585 Mg (Khajuri), which is higher than the consumption rate reported for many Indian villages such as Haripur complex (0.642 t $year^{-1}$) of Odisha (Sahoo 1993), Sitting (0.59 t $year^{-1}$) Tamil Nadu (Dhenapal 1992), Bhgibandha 0.53 t yr^{-1} tribal village (Nayak et al. 1993) and Bhabinara-Yampur (0.59 t yr^{-1}) an agricultural village of Odisha (Nisanka and Misra 1990), Uchangi (0.84 t yr^{-1}), Karnatak (Mishra et al. 1983). The average fuel wood consumption per household (family) reported in the study is well within the range reported for many villages. The value ranges from 8.626 kg $family^{-1}$ day^{-1} (Rodanga) to 16.727 kg $family^{-1}$ day^{-1} (D. Kumbharbadi). These values are similar to the value of Himalayan foothill villages (Moench 1989) but less than that of tribal villages in Odisha (Mohapatra 1992). Firewood is used as fuel energy for all villages and also meets the family income by selling firewood after collecting for a forest. This agrees with the data reported for many Indian villages (Gangwar and Ramakrishnan 1987). Easy access to firewood and subsistence village economy is responsible for 100% dependency on biomass energy. Mud stove cooking is the reason for the high consumption of firewood with far less heat utilization efficiency of 20.35% (Nisanka and Mishra 1989).

The sustainability of village ecosystem

The village ecosystem has three major sub-systems: agriculture, animal husbandry, and domestic. All these are interrelated among themselves and with the forest ecosystem. The relation can be described through the quantity of energy flow and its sustainability. The deficit of the village ecosystem is met by procuring materials from outside these systems. The agriculture sub-system production is insufficient to meet the villagers' food requirements. PDS rice is received (imported) to meet the gap.

Table 17. Per capita food consumption in the village ecosystem (g cap^{-1} day^{-1})

Items	Patlamba	Rodanga	Khajuri	Gortali
Rice	299.53	388.21	228.10	226.37
Maize	4.18	4.18	19.59	24.32
Finger millets (Mandia)	128.18	101.95	158.21	188.78
Pearl millets (Ghantia)	20.25	7.62	11.35	17.76
Common millets (Kangu)	77.64	29.97	14.98	27.16
Barnyard millets (Koshala)	118.81	106.23	77.41	91.22
Redgram legumes (Kandul)	26.61	10.93	13.51	25.77
Jhudanga	9.37	18.42	25.82	47.75
Kating	19.58	12.35	21.31	13.41
Vegetables	69.68	22.21	14.81	18.03
Turmeric	2.68	2.49	2.14	2.76
Ginger	1.67	1.19	1.34	1.80
Jack Fruit	17.57	11.45	5.97	17.69
Orange	-	0.90	0.36	0.21
Pineapple	33.63	5.68	67.31	51.41
Papaya	11.55	25.89	28.49	10.43
Dry food	6.19	5.44	1.26	1.11
Meat/others (fresh wt)	6.29	3.41	0.85	0.83
Dry fish (marine)	5.32	3.55	1.75	1.60
Sugar	0.50	0.50	0.36	0.48
Molasses	0.84	0.90	0.98	0.83

Table 17. Per capita food consumption in the village ecosystem (g cap^{-1} day^{-1}) (*Continued*)

Items	Majhihalma	Bhaliabhatta	D. Kumbharbadi	Papikhunti
Rice	529.62	411.73	767.36	194.44
Maize	28.70	26.85	24.44	18.81
Finger millets (Mandia)	132.78	84.26	122.78	118.63
Barnyard millets (Koshala)	-	-	-	153.36
Redgram legumes (Kandul)	28.20	20.22	19.86	63.80
Jhudanga	21.30	22.38	21.81	-
Vegetables	26.76	29.78	39.31	51.65
Jack fruit	16.30	13.89	24.44	6.08
Papaya	6.48	9.26	25.00	14.47
Dry food	1.33	1.20	1.19	1.19
Meat/others (fresh wt)	1.11	1.20	0.92	1.07
Dry fish (marine)	2.11	2.04	1.75	1.71
Sugar	0.56	0.62	1.11	0.58
Molasses	0.65	0.77	0.69	0.58
Tobacco	0.74	0.31	1.67	0.58

The uphill villages sell a good quantity of minor millets and horticulture products (jackfruit, pineapple, banana, orange, mango) which can be recorded as high energy value. The forest ecosystem contributes more to the village's energy production in these village ecosystems. Thus, it is essential to make forests productive for sustainable productivity. An alternative source of firewood must be provided on a priority basis as the share of firewood in the village energy production was 60.61% average in the uphill village and 65.51% in foothill villages. Firewood consumption, whether for domestic use or sold outside, should be addressed immediately to reduce dependency on the forest. Regeneration of *S. robusta*, *Madhuca latifolia* and *T. indicus* and *Caryota* palm in and around forest lands may be encouraged as these trees are intimately connected to the livelihood and cultural practices of tribal communities. Planting short-rotation crops like bamboo, leafy vegetable of forest species and tuber crops can meet village needs. The siali climber can cover exposed rocks besides providing siali leaves nearer to habitations. Suitable soil and moisture conservation measures are required to retain water (above ground and below ground) for a longer time on hill slopes, increasing the productivity of forest and agricultural crops. Agriculture production is important to provide food directly to the tribal community. Since the community is addicted to a set of crops, it is essential to enhance existing crop productivity. The share of agriculture production in the total village production was 27.07% in uphill villages and 26.12% in foothill villages. Training villagers for their traditional crop production and infrastructure development can strengthen the sustainability of agriculture production. Since the literacy rate is very low except in the village of D. Kumbharbadi, it is also suggested to improve literacy so that the population will accept technology input.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support from the local staff of Odisha Forest Department, India, and the entire village population of the villages of Niyamgiri Hills, India, during the study period.

REFERENCES

Abel N, Cork S, Gorddard R, Langridge J, Langston A, Plant R, Proctor W, Ryan P, Shelton D, Walker B, Yialeloglou M. 2003. Natural Values: Exploring Options for Enhancing Ecosystem Services in the Goulburn Broken Catchment. CSIRO (Commonwealth Scientific and Industrial Research Organisation) Sustainable Ecosystems [now CSIRO Ecosystem Sciences], Canberra. Available at: www. ecosystemservicesproject.org/ html/ publications/ docs/nveo/ Natural Values.pdf (accessed December 2012).

Aida GR, Wardiatno Y, Fahrudin A, Kamal MM. 2016. Dynamic model on the economic value of mangrove ecosystems in Tangerang Coastal Area, Banten. Bonorowo Wetlands 6: 26-42. DOI: 10.13057/bonorowo/w060103.

Akachukwa AE. 1985 cost-benefit analysis of wood and food components of agriculture in Nigerian forest zone. Agrofor Syst 3: 307-316. DOI: 10.1007/BF00055714.

Altieri MA. 1980. Agro Ecology: The Science of Sustainable Agriculture Westview Press, Boulder, CO USA.

Altieri MA. 1995. Agroecology: The Science of Sustainable Agriculture. Westview Press, Boulder, CO USA.

Anderson A. 1990. Alternatives to Deforestation: Steps Towards Sustainable Use of Amazon. Rain Forests. Colombia Univ Press, New York.

Bennet EM, Cumming GS, Peterson GD. 2005. A systems model approach to determining resilience surrogates for case studies. Ecosystems 8: 945-957. DOI: 10.1007/s10021-005-0141-3.

Census. 2011. Census of India 2011. Odisha Series-22 Part XII-A Rayagada (891p.) and Kalahandi(1031 p.). District Census Handbook. Directorate of Census Operations, Odisha, Ministry of Home Affairs, Bhubaneshwar, India.

Conway GR. 1997. The Doubly Green Revolution. Penguin Books, London.

CSIR 1992. The Wealth of India. Raw Materials Vol. III: Ca-Ci," Publications and Information Directorate, New Delhi, India.

Dasmann RF. 1988. Bisphere Reserves, Buffers and Boundaries. Bioscience 38: 487-489. DOI: 10.2307/1310953.

District Statistical Hand Book Raygada. 2011. Directorate of Economics and Statistics, Government of Odisha. Bhubaneswar, India.

Dwivedi AP. 1989. Mahua: A food form forest. Vanik Sandesh 13 (3): 13-16.

FAO 1993. Shifting Cultivars of Indonesia: Marauders or Managers of the Forest. Community Forestry Case Study series, FAO, Rome.

Gangwar AK, Ramakrishnan PS. 1987. Agriculture and animal husbandry among the Sulungs and Nishis of Arunachal Pradesh. Soc Action 37: 345-372.

Gliessman SR. 2007 Agroecology: The Ecology of Sustainable Food System. 2nd Edition. USA, CRC Press, Boca Raton.

Godfray HCJ, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, Pretty J, Robinson S, Thomas SM, Toulmin C. 2010. Food security: The challenge of feeding 9 billion people. Science 327 (5967): 812-818. DOI: 10.1126/science.1185383.

Gomez-Pompa A, Vasquez-YanesG, Gueraro S. 1972. The tropical rain forest: A non-renewable resource. Science NY 177: 762-765. DOI: 10.1126/science.177.4051.762.

Gopalan C, Sastri BVR, Balasubramaniam SC. 1982. Nutritive Value of India Foods. National Institute of Nutrition, ICMR, Hyderabad.

Hall DO, Barnard GW, Moss PA. 1982. Biomass for Energy in the Developing Countries – Current Role, Potential, Problems, Prospects. Pergamon Press, Oxford.

Jarvis DI, Brown ADH, Imbruce V,Ochoa J, Sadiki M, Karamura E, Trutmann P, Finckh MR. 2007. Managing Crop Disease in Traditional Agro Ecosystem, Colombia University Press, New York.

Lambin EF, Myfroidt P. 2011. Global land use change, economic globalization- and the looming land scarcity. Proc Natl Acad Sci 108 (9): 3465-3472. DOI: 10.1073/pnas.1100480108.

Landis DA, Wratten SD, Gurr GA. 2000. Habitat management to conserve natural enemies of arthropod pest in agriculture. Ann Rev Entomol 45: 175-201. DOI: 10.1146/annurev.ento.45.1.175.

Maikhuri RK, Rao KS, Saxena KG. 2004. Bio prospecting of wild edibles for rural development in Central Himalaya. Mt Res Dev 24: 110-113. DOI: 10.1659/0276-4741(2004)024[0110:BOWEFR]2.0.CO;2.

Mishra BK, Hegde MS, Subramanian DK, Prasad SN. 1983. Studies on Village Ecosystems of North Kanara District of Karnataka. Technical Report 12, Centre for Ecological Sciences, Indian Institute of Sciences, Bangalore, India.

Mishra BK, Ramakrishnan PS. 1982. Energy flow through a village ecosystem with slash and burn agriculture in North-eastern India. Agric Syst 9: 57-72. DOI: 10.1016/0308-521X(82)90040-3.

Mitchell R. 1979. An analysis of Indian Agro-ecosystems. Interpreters, New Delhi.

Moench M. 1989. Forest degradation and the structure of biomass utilization in Himalayan Foothills Village. Environ Conserv 16: 137-146.

Nautiyal S, Maikhuri RK, Rao KS, Semwal RL, Saxena KG. 2003. Agroecosystem function around a Himalayan Biosphere Reserve. J Environ Syst 29: 71-100.

Nayak SP, Nisanka SK, Mishra MK. 1993, Biomass and energy dynamics in a tribal village ecosystem of Orissa India. Biomass Bioenergy 4: 23-34. DOI: 10.1016/0961-9534(93)90024-X.

Nisanka SK, Mishra M.1989. Ecological Study of an Indian Village Ecosystems: Energetics Biomass. Elsevier Science Publisher Ltd., England.

Nisanka SK, Mishra MK. 1990. Ecological study of an Indian village ecosystem. Biomass production and consumption. Biomass 23: 117-136. DOI: 10.1016/0144-4565(90)90030-N.

Phalan B, Onial M, Balmford A, Green RE. 2011. Reconciling food production and biodiversity conservation: Land sharing and land sparing compared. Science 333 (6047): 1289-1291. DOI: 10.1126/science.1208742.

Prasad R. 1992. Mahua, The Tree of Poor. International Book Distributors. Dehradun.

Rabindranath NH, Hall DO. 1995. Biomass, Energy and Environment: A Developing Country Perspective from India, Oxford University Press, New York.

Ramakrishnan PS. 1985. Tribal man in the humid tropics of the North-East. Man in India 65: 1-32.

Rao KS, Maikhuri RK, Nautiyal S, Saxena KG. 2003. Local people's knowledge,aptitude and perceptions of planning and management issues in Nanda Devi Biosphere Reserve, India. Environ Manag 31: 168-181. DOI: 10.1007/s00267-002-2830-4.

Rao KS, Nautiyal S Maikhuri RK, Saxena KG.2000. Management conflicts in the Nanda Devi Biosphere Reserve, India. Mt Res Dev 20: 320-323. DOI: 10.1659/0276-4741(2000)020[0320:MCITND]2.0.CO;2.

Ravelle R. 1976. Energy use in Rural India. Science 192: 969-975. DOI: 10.1126/science.192.4243.969.

Sahoo HP, Mishra MK. 1992. Ecological study of an Indian coastal village ecosystem. Intl J Environ Stud 39: 257-266. DOI: 10.1080/00207239208710701.

Sahoo HP. 1993. Ecological Studies on Indian Coastal Village Ecosystem. [Thesis]. Berhampur University, Berhampur. [India]

Schenldar RR. 1995. Government and the Economy on the Amazon Frontier. World Bank, Washington, D.C.

Sukla PK, Pandey RK. 1993. Tribal life and forest: A case study of selected forest villages in Dindori Tehasil of Mandla District in Madhya Pradesh. J Trop For 9 (4): 287-306.

Toky OP, Ramakrishnan PS. 1981. Cropping and yields in agricultural systems of the north-eastern hill region of India. Agro-Ecosyst 7: 11-25. DOI: 10.1016/0304-3746(81)90012-3.

Tomich TP, Brodt S, Ferris H, Galt R, Horwath WR, Kebreab E, Leveau JHJ, Liptzin D, Lubell M, Merel P, Michelmore R, Rosenstock T, Scow K, Six J, Williams N, Yang L. 2011. Agroecology: A review from a global charge perspective. Ann Rev Environ Resour 36: 193-222. DOI: 10.1146/annurev-environ-012110-121302.

Van der Maarel E. 1993. Some remarks on disturbances and its relations to diversity and stability. J Veg Sci 4: 733-736. DOI: 10.2307/3235608.

Watson GA. 1983. Development of mixed tree and food crop system in the humid tropics: A response to population pressure and deforestation. Exp Agric 19: 311-332. DOI: 10.1017/S0014479700012771.