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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

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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.

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Review: Ethno-zoological study of animals-based medicine used by traditional healers of Northeast India

JAFRIN FARHA HUSSAIN♥, HERO TYNSONG♥♥
Ministry of Environment, Forest and Climate Change, Integrated Regional Office, Law-U-Sib, Madanriting, Shillong-793021, Meghalaya, India.
♥email: jafrinfarhahussain@gmail.com: ♥♥ h.tynsong78@gmail.com

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Abstract. *Hussain JF, Tynsong H. 2021. Review: Ethno-zoological study of animals-based medicine used by traditional healers of Northeast India. Asian J Ethnobiol 4: 1-22.* For ages, plants and animals have been used in human cultures as therapeutics. Animals have not only acted as a source of food for humans but have also been commonly used in applications such as medicine, clothes, and other related services. The use of animals and animal products in traditional methods of treating diseases, and for many different reasons, dates back to the early days of civilization. Treatment of human diseases using animal-derived products is called zootherapy or ethno-zoology. Despite the worldwide utilization of ethno-zoology in the form of traditional medicines based on animals, a thorough study of zootherapy in comparison to plant-based medicinal research is still ignored. This study highlights available knowledge on ethno-zoological therapeutic applications used by different traditional healers of North-East (NE) India. Concerning the frequency of animal species, the use of mammals and mammalian products is the highest in NE India compared to other animal groups. In contrast, the use of fish-based medicine in the state of Manipur is prevalent compared to other animal species. In Arunachal Pradesh, the use of insects is high in traditional medicines.

Keywords: Animals-based medicines, ethno-zoology, North-East India, traditional knowledge

INTRODUCTION

The treatment of human diseases using animals and animal-derived treatments is known as zoo therapy (Costa-Neto 1999). World Health Organisation (WHO 1993) reported that around 70-80% of the world's rural population relies for primary health care on traditional medicine. Using animals and their products to treat patients suffering from various health problems has a long tradition. It is still prevalent in many parts of the world, even when medical science has achieved great heights (Jugli et al., 2019). WHO (2014) estimates that in developing countries, the proportion of the population using traditional medicine is considerably higher (60-90%) compared to developed countries (23-80%).

Knowledge of traditional medicines by indigenous communities worldwide that help them heal, avoid, and mitigate diseases is derived from their cultural traditions, indigenous values, ideas, and rituals (Young 1983; Janes 1999). Animal-based treatments are successful in several applications, and in recent times, they constitute a significant part of traditional pharmaceutical products (WRI 2000). Anageletti et al. (1992) and Rosner (1992) reported that animals and their products had been used internationally in traditional treatments, playing significant roles in healing practices, magic rituals, and religious practices amongst various cultures and communities.

Animal-based medicines are usually obtained from three sources: (i) the entire body or its smaller parts, (ii) metabolic products such as secretions or excreta, and (iii) other items produced by animals like nests, coconuts, honey, eggs, etc. (Costa-Neto 2005). In recent times, the application of zootherapy has been considered the foremost reliable primary alternative among many other known therapeutic practices in the world (Kendie et al., 2018). The traditional knowledge of indigenous people around the globe has played a crucial role in identifying living organisms endowed with medicinal values; and is essential for treating human health problems (Kendie et al. 2018).

Over several hundred years, communities and societies have slowly developed a large store of information on animals that could be closely combined with different aspects of cultures and customs, thereby providing new possibilities for other cultural strategies(Alves 2012). WHO has previously selected 252 essential chemicals for medicinal purposes, of which 11% are of plant origin, and 9% are of animal origin (Marques 1997). While this shows that traditional based medicines derived from plants and their derivatives have been studied in more detail (Werner 1970; Ragupathy et al. 2008; Ragupathy and Newmaster 2009; Polat et al. 2015; Silambarasan and Ayyanar 2015; Bhatti et al. 2017; Faruque et al. 2018), however, the identification of animal resources for medicinal and human health care is equally important and requires extensive research (Alves and Rosa 2005; Costa-Neto 2005).

India is home to large ethnic and indigenous communities (von Fürer-Haimendorf 1982) relying heavily on plants and animals for their medicine (Sarmah et al. 2006; Tynsong et al. 2006), food (Dutta and Dutta 2005; Tynsong et al. 2012a, b), shelter (Cavendish 2000), clothing (Mao et al. 2009), etc. Borah and Prasad (2017) reported that many indigenous communities in India have recently begun opting for traditional animal-based medicines as an alternative to other health care systems. Animal by-products such as hooves, scales, bones, feathers, tusks, etc. have acted as essential ingredients for the preparation of some curative medicines and drugs (Adeola 1992; Anageletti et al. 1992; Kang and Phipps 2003). Documentation of the country's traditional methods of healing using animal-based medication is essential for establishing new medicinal prospects and remedial measures for several unknown diseases (Borah and Prasad 2017).

The Indian traditional knowledge system on medicine has declines due to the steady increase of urbanization and other anthropogenic factors (Das 2015). Therefore, it is vital to understand and record the knowledge available on animal-based therapeutics practiced by local healers among different indigenous communities before these traditional cultures and practices are forbidden and lost (Trivedi 2002). However, overexploitation of animals may jeopardize species' survival rate, causing ecosystem imbalances (Tynsong et al. 2020). Therefore, to preserve the proper harmonious life of humans and animals in the use of animal-based medicines, documentation is necessary to understand the everyday use of animals and animal products by local healers as a source of traditional therapy (Chakravorty et al. 2011a, b).

Studies on plant-based traditional medicine have been comparatively more in North-east (NE) India (Dutta and Dutta 2005; Sajem and Gossai 2006; Mao et al. 2009; Chakraborty et al. 2012; Prakash et al. 2014; Tynsong et al. 2020) compared to animal-based traditional medicines (Lalramnghinglova 1999). The lack of information is mainly because knowledge of animals-based traditional medicine is usually passed orally from one generation to the next, and this information is slowly lost as the knowledge bearers die (Borah and Prasad 2017). The present study is aimed to review and discuss the status of traditional animal-based medicines in NE India.

STUDY AREA

NE India is part of the Indo-Burma biodiversity hotspot and accounts for 8% (about 262,179 sq. km) of India's total geographic area (Tynsong et al. 2020). NE India has eight states, namely Arunachal Pradesh, Assam, Manipur, Mizoram, Meghalaya, Nagaland, Tripura, and Sikkim (Figure 1). Arunachal Pradesh is a culturally rich state of NE, India, and is the largest (area-wise) with rich alpine geographical diversity and a wider variety of wildlife (Saio and Upadhyay 2018). NE India is considered a home to many indigenous communities and groups with varying social-cultural practices, following a wide variety of cultural diversity, and leading a life largely dependent on the biological resources around them (Ripunjoy and Indira 2012; Teron and Borthakur 2012).

Mao et al. (2009) recorded that NE India is inhabited by more than 200 indigenous communities with distinct cultural entities, the while the 2011 census reports that NE India is home to 427 tribal groups with their own traditional and cultural identities (Borah and Prasad 2017). These indigenous communities possess a wide range of traditional knowledge on traditional medicines (Tynsong et al. 2020). It is crucial to record such an information structure before it gets lost forever inside the rapid push of modernization and globalization. The number of significant and sub-indigenous communities in NE India as reported by various researchers is summarized in Table 1.

North-east India's indigenous people have long been dependent on traditional medicine for their overall health and wellbeing (Jamir and Lal 2005; Kalita et al. 2005; Mao et al. 2009; Tynsong et al. 2020). For example, Arunachal Pradesh's Nyishi and Galo communities use edible and therapeutic insects and vertebrate species to treat various ailments (Chakravorty et al. 2011a), while ethnic communities of Nagaland use different animals to treat asthma, tuberculosis, rheumatic pain, and paralysis (Jamir and Lal 2005). In Meghalaya, the use of animals for various ailments is recorded among the Khasi community in their natural, zoo-therapeutic traditional methods (Mihsill and Keshan 2017; Turnia and Prasad 2017). A wide variety of traditional plant-based medicines (Sajem and Gossai 2006), animals, and often mixed plant and animal formulations (Kalita et al. 2005) were recorded from the state of Assam. Ethno-zoological applications reported from Manipur, Sikkim, Mizoram, and Tripura are also discussed in this paper.

DATA ANALYSIS

Data sources

The present research work is focused on the original reports and findings and review papers. In this study, a survey of the initial investigations was mainly considered. The definitions are based on the authors' study of the knowledge on ethno-zoology available in NE India. Most of the literature has been cited/downloaded from journals and online sources such as Research Gate, Google Scholar, Academia.edu, and the respective journals' official websites. The IUCN Red List of Endangered Species (IUCN 2020) was used to determine the conservation status of the different animal species used for traditional medicine by various indigenous groups of NE India.

State-wise analysis

State-wise analysis in the results has been presented in alphabetical order according to the names of the North-Eastern Indian States. With the aid of Microsoft (MS) Excel, quantitative evaluation of data concerning the use of animal groups among different indigenous communities in NE India has been conducted. The analysis of the present paper was intended to include and incorporate the available knowledge recorded in NE India on traditional medicine using animals. The present report is based on the compilation of literature surveys of general knowledge on ethno-zoological activities prevalent in all eight North-east Indian states from 1999 to October 2020; and is discussed hereunder.

DETAILED REPORT OF EACH STATE

A survey on the available literature of ethno-zoological applications by traditional healers in all the Northeast Indian states has helped identify various animal groups used for medicinal purposes. A The present paper has discussed a detailed report on available literature pertaining to each state.

A summary of the available literature and research findings on ethno-zoological studies in NE India, with details of animal groups and their body parts used for several diseases, are presented in Table 2.

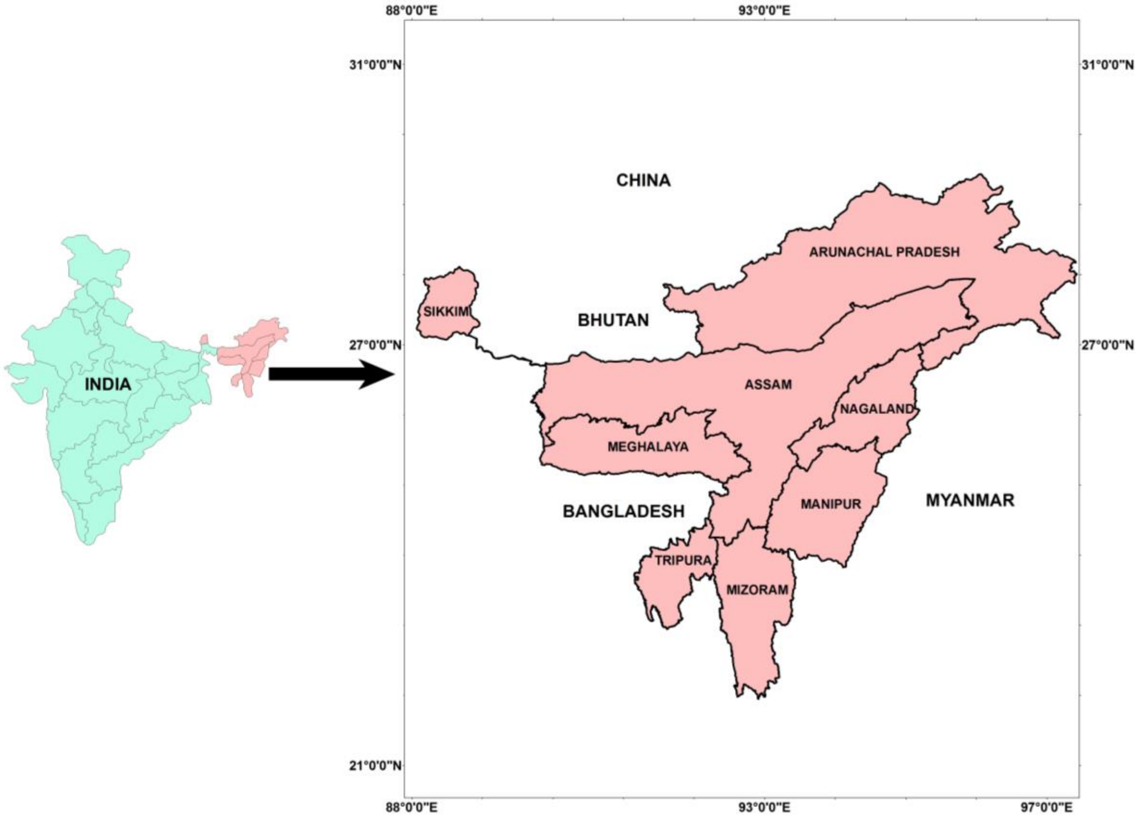

Figure 1. Location map of North-east India

Table 1. Number of major and sub-indigenous communities in North-east India as reported by various researchers

State	No. of major indigenous communities	No. of sub-indigenous communities	Referred literature(s)
Arunachal Pradesh	20	17	Dutta and Dutta (2005), Tynsong et al. (2020)
Assam	62	16	Dutta and Dutta (2005), Tynsong et al. (2020)
Manipur	29	-	Dutta and Dutta (2005), Tynsong et al. (2020)
Meghalaya	22	-	Dutta and Dutta (2005), Chakraborty et al. (2012), Tynsong et al. (2020)
Mizoram	15	45	Dutta and Dutta (2005), Chakraborty et al. (2012), Tynsong et al. (2020)
Nagaland	36	16	Chakraborty et al. (2012), Tynsong et al. (2020)
Sikkim	3	-	Dutta and Dutta (2005), Chakraborty et al. (2012), Dhakal et al. (2019)
Tripura	19	-	Chakraborty et al. (2012), Das (2015), Tynsong et al. (2020)

Note: '-' signifies not reported

Table 2. Ethno-zoological studies of animal groups and their body parts used for several diseases in NE India

State	Indigenous community	No. of animal species used	Body parts used	Ailments/Diseases	Author(s)
Arunachal Pradesh	Monpa	11 (mammals, birds)	Meat, gall bladder, bones, musk, musk gland of musk deer, fat.	Malaria, typhoid, tuberculosis, fever, rheumatic pain, diarrhea, smallpox, cholera, magico-religious purposes.	Solanki and Chutia (2004)
	Nyishi	13 (mammals, birds, reptiles)	Skin, claw, teeth, meat, musk, pod, tusk, gall bladder, fat.	Rheumatic pain, dysentery, jaundice, intestinal troubles, infections, liver and heart diseases, cough, hypertension, malarial fever, swelling, burn, joint fractures, impotency.	Solanki et al. (2004)
	Nyishi	18 (mammals, birds, reptiles)	Gall bladder, horn, penis, meat, bone, fat, testis, exoskeleton, alimentary canal.	Malaria, typhoid, dysentery, feminine problems, rheumatic pain, pox, wounds, abdominal pain, weakness.	Solanki et al. (2005)
	Galo	16 (insects)	Whole body, hive, larva, adult.	Additional nutrition for nutritional deficiency.	Dagyom and Gopi (2009)
	Apatani, Nyishi, Monpa	100 (mammals, birds, reptiles, fish, mollusks, arthropods)	Whole animal, meat, bone, fat, skin, gall bladder, gut, shell, alimentary canal, penis, horn, blood, mucus, feathers and legs (birds).	Jaundice, indigestion, stomach ailments, asthma, tuberculosis, dysentery, boil, snake and scorpion bites, cough, headache, bronchitis, stroke, hallucination, wound, pox, anemia, weakness, skin disease, malaria, piles, rheumatic pain, typhoid, nasal congestion, night blindness, paralysis, impotency.	Solanki and Chutia (2009)
	Nyishi, Galo	81 (local insects)	Whole insect, larval stages, nymphs, adult stages, pupae, eggs.	Cough, fever, stomach ailments, skin irritation, scabies, toothache, high blood pressure, boil, wounds, malaria, dysentery, chest pain.	Chakravorty et al. (2011a)
	Nyishi, Galo	36 (vertebrates)	Mucus, stomach, gut, fins, bones, whole body, fats, flesh, feathers, testicles, frontal bone, skin, intestine, nails, blood, bone marrow.	Burns, stomach ache, digestive problems, body burns, diarrhea, smallpox, wound healing, joint pain, diseases in cattle, early pregnancy, tuberculosis, gastritis, jaundice.	Chakravorty et al. (2011b)
	Adi	39 (aquatic and terrestrial)	Bones, meat, skull, wings, eggs, tail, gall bladder, ant larvae.	Diabetes, weakness, fertility enhancement, malaria, skin disease, joint pain, taboos and spiritual purposes.	Chinlampianga et al. (2013)

	Wancho and Tangsa	Tangsa:55 Wancho: 20 (vertebrates and invertebrates)	Gall bladder, bile, body fat, flesh, liver, lactating breast, tooth, scales, blood, whole body, stomach, intestine, wings/appendages, brain, urinary bladder, excreta, bone marrow, limb bones, budding tender antlers (Sambar and Hog deer), urine, tail fat (Pied hornbill and domestic chicken), head and shell (tortoise), honey (bees), live leech, hemolymph.	Common day-to-day disorders, general weakness, body pain, fever, asthma, allergies, diarrhea, stomach ailments, cough, cold, dermal conditions, hemorrhoids, diabetes, burns, jaundice, liver problem, earache, malaria, epilepsy, tuberculosis, cancer, venomous snake bites.	Jugli et al. (2019)
Assam	Ethnic communities of Dibrugarh	4 (fishes)	Edible portion of fish, blood.	Body pain, carbuncle, diabetes, obesity.	Kalita et al. (2005)
	Karbi	14 (mammals, birds, insect, mollusk, reptiles, crustaceans)	Decayed flesh, saliva, whole body, elephant teeth, raw blood, meat, feather (Crane), legs (goat, deer), gall bladder, bile, fat.	Corn, eye disease, jaundice, itch, tuberculosis, joint pain, fever, infections, urinary problems, rheumatic pain, chest pain, stomach disorder, headache, haircare.	Hanse and Teron (2012)
	Karbi	14 (fishes)	Whole fish, raw blood, head, bile, belly, fats, brain, flesh, eyes.	Depression, anemia, kala-azar, constant spitting, weakness after delivery, night blindness, smallpox, wounds, dysentery, common cold, rheumatism, arthritis, stomach ache, corn, testicle swelling, malaria.	Teronpi et al. (2012)
	Biate	34	Gall bladder, flesh, fat, whole body, brain, scales, bone, skull bone, hand, front foot, urine, fur, blood, teeth, tongue.	Diabetes, snake bite, seizure, sprain, piles, burn, jaundice, impotency, allergy, rheumatic pain, tuberculosis, arthritis, gall stone, joint pain, malaria, dizziness, hernia, epilepsy, mumps, toothache, food poisoning, hair care, blood pressure.	Betlu (2013)
	Karbi	48 (mammals, insects, birds)	Insects: Honey, whole body, hind legs. Annelids: Live leech. Amphibians: Hind legs, skin, whole body, flesh Reptiles: Fat, whole body, blood, heart, eggs. Birds: Feathers, flesh, blood, fat, excreta. Mammals: Milk, urine, fat, dung, penis, bile, testicle, liver, droppings, blood.	Cough, flu, asthma, diuretic, baldness, lung infection, throat inflammation, anti-cancer, warts, rabies, arthritis, urinary tract problems, wounds, tongue blister, piles, joint pain, leprosy, stammering, paralysis, typhoid, toothache, blood pressure, breathing problem, nasal congestion, whooping cough, rheumatism, dysentery, tumors, bronchitis, anemia, eczema, malaria, jaundice, tuberculosis, asthma, cancer, skin disease, conjunctivitis.	Verma et al. (2014)
	Nath, Karbi	26 (mammals, fishes, birds, annelids, insects, reptiles)	Meat, urine, skin, alimentary canal, dung, oil, whole insect, honey, whole body, whole fish, blood.	Diarrhea, blood pressure, dysentery, bone fracture, asthma, jaundice, chickenpox, liver disease, tonsil, body ache, leucorrhea, skin disease, female infertility, joint pain, blood cancer, pneumonia, cough, burn, piles, skin disease, abdominal pain, polio, dysmenorrhoea, tuberculosis.	Borah and Prasad (2016)

	Ahom, Chutia, Koch-Rajbonshi, Kalita, tea tribes (Adivasis).	44 (insects, mammals, fishes, reptiles, annelids, amphibians, gastropods)	Whole body, soft watery portion, cocoon with larva (insects), head, heart with blood, meat, gall bladder, whole fish, milk, urine, horn, alimentary canal.	Asthma, otorrhoea, cancer, pain, sinus, epistapix, fever, eyesight, pneumonia, vocal cord infection, piles, impotency, bone fracture, gastric ulcer, wounds, anemia, blood pressure, pox, snake bite, skin disease, tonsil, rabies, chronic dysentery, paralysis.	Borah and Prasad (2017)
Manipur	Different ethnic groups of Manipur	33 (28 vertebrates, 5 invertebrates)	Invertebrates: Whole body, honey. Vertebrates: Whole fish, raw blood, bile, flesh, fat, brain, bone, leg, milk, urine, meat, intestine, fur.	Asthma, diabetes, tuberculosis, urine problems, antidote in snake bites, stomach disorders, eye problems, jaundice, liver disorders, body ache, wounds, anemia, common cold, smallpox, diarrhea, malaria, rheumatic pain, arthritis, skin disease, piles, hair care, and magico-religious purposes.	Devi et al. (2015)
	Meitei, Meitei Pangals, Chothe, Kabui, Kom	21 (fishes)	Whole body, liver, bile, eye, operculum, flesh, body oil, barbels.	Night blindness, chronic fever, piles, meningitis, constipation, deworming, ripening/swelling of boils, vitamins and general body tonic, anemia, malnutrition, post-delivery diet, lactation, tuberculosis, blood purifier, arthritis, cracked heels, night blindness, scurvy, food poisoning, brain improvement, kwashiorkor, dysentery, vaginal problems, ringworm, plague, ulcer.	Chanu et al. (2016)
	Rongmei	26 (mammals, birds, reptiles, amphibians, mollusks, insects)	Mammals: Bone, flesh, urine, bile, tongue, bone marrow, fat, stomach, hand/palm, penis, hair, whole body, leg, milk. Birds: Fat, whole bodies, bone, flesh. Reptile: Body and fat. Amphibian: Body. Mollusc: Whole body Insect: Whole body.	Tuberculosis, stomach disorder, stone case, alcoholic addict, wounds, injuries, sprains, cough, typhoid, boil, malaria, unconsciousness, epilepsy, burns, frequent urination, impotency, eye pain, bone joining, white discharge, skin diseases and cancer.	Ngaomei and Singh (2016)
Meghalaya	Khasi	13 (mammals, annelids, arthropods, fishes)	Whole body, fat/oil, bile, milk (tigress), fetus (pregnant deer), live fish, whole leech, insect intestine.	Malaria, burns, breastfeeding problems, tongue blemish of infants, boils, whooping cough, rash, wounds.	Mihsill and Keshan (2017)
Mizoram	Mizo	56 (25 vertebrates, 31 invertebrates)	Bones, ribs, hair, meat, blood, brain, bone marrow, bile, male organ, fatty oil, milk, scrotum, urine, tongue, tooth, stomach, intestine, toes, feathers, quill, fluids from neck.	Jaundice, convulsions, fractures, swellings, measles, liver ailments, tuberculosis, inflammatory glands, boils, chronic ulcers, asthma, chickenpox, bee sting, rheumatism, fever, headache, itch, pneumonia, piles, splenomegaly, diphtheria, whooping cough, weakness, otorrhoea, snake bite, night blindness, easy labor.	Lalramnghinglova (1999)
	Mizo	48	Fat, feathers, hair, bile, blood, urine, skull, fatty oil, meat, bone, skin, milk, liver, horn, tongue, intestine, rectum, male organ, brain, ribs.	Cough, asthma, tuberculosis, paralysis, earache, weakness, muscular pain, malarial fever, convulsion, diabetes, arthritis, leprosy, wounds, burns, diarrhea, respiratory ailments, kidney problems, cholera, hypertension, jaundice, liver problems, etc.	Chinlampianga et al. (2013)

	Mizo, Bru and Chakma	22 (mammals, reptiles, birds)	Gall bladder, bones, brain, blood, tooth, fat, nails, liver, stomach, intestine, meat, quill, scales.	Stomach ache, dysentery, diarrhea, cholera, malaria, epilepsy, vitamin, supplement, facilitate labor pain, strengthening of bones, stunted growth in infants, to protect body from evil soul, tooth decay, high blood pressure, asthma, epilepsy, convulsion, birth control, hair care, itching, kidney problem, diabetes, pneumonia, burns, cholera, cough.	Solanki et al. (2016)
Nagaland	Chakhesang	23 (mammals, reptiles, birds, amphibians, fishes, mollusk, annelids, arthropods)	Gall bladder, penis, hair, fat, urine, blood, spine (porcupine), small intestine, stomach, flesh, scale, bone marrow, feather, liver, skin, slimy mucus (fish), mollusk shell, honey from bees.	Wounds, thorns in flesh, gestation/child delivery, burn, swelling, stomach pain, anemia, bone fracture, gastritis, malarial fever, urethritis, constipation, cough, typhoid, tongue blisters, earache, dysentery, chickenpox.	Kakati and Doulo (2002)
	Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma	26 (mammals, birds, amphibians, reptiles, annelids, insects, crustaceans)	Whole body, flesh, fresh blood, fat, skin, gall bladder, bile duct, penis, urine, teeth and tusks (elephant), intestine, milk (goat), urine.	Antidote in snake and spider bites, asthma, stomach ache, tuberculosis, eye problems, jaundice, liver disorders, rheumatic joint pain, anemia, weakness, burns, wounds, fractures, earache, aphrodisiac, general weakness, night blindness, impotency, chest pain, fever, pile, facilitating delivery, leukoderma, eczema, ringworm, breast pain of lactating mothers, cholera, dysentery, cataract, food poisoning.	Jamir and Lal (2005)
	Ao	25 (vertebrates) (mammals, birds, reptiles, amphibians, fishes)	Fat, flesh, bile, tooth, intestine, bile, urine, liver, legs, milk, penis, blood, bones, skin.	Body pain, sprain, rheumatism, asthma, liver cirrhosis, leukoderma, itch, eczema, ringworm, anti-poison, tuberculosis, paralysis, skin disease, stomach disorder, jaundice, night blindness, fracture, weakness, breast pain of lactating mothers, impotency, burn, snakebite, malaria, dysentery, kidney stones, breathing problem, earache, stammering, piles, snake bites, wounds.	Kakati et al. (2006)
Sikkim	Lepcha, Bhutia and Nepali (including sub-communities)	59 (mammals, birds, insects, amphibians, reptiles, lower groups)	Mammals: Gall bladder, bones, meat, teeth, horn, skin, musk gland (Himalayan Musk Deer), scales, fur, urine, milk. Birds: Meat. Reptile: Molted skin (King Cobra). Amphibian: Meat, egg. Insects: Body, honey. Others: Spider web, crab and snail meat, whole worm	Fever, liver problems, heart disease, diabetes, wounds, body ache, dysentery, asthma, rheumatism, piles, gout, joint pain, tuberculosis, epilepsy, parturition, food poisoning, constipation, ear pain, cough, cold, urinary tract infection, immunity booster, pneumonia, bone fracture, snakebite, malaria, bedwetting, burns, eye pain, nose bleed, improvement of vision, ulcers.	Dhakal et al. (2019)
Tripura	Tripuri, Jamatia and Reang	25 (vertebrates and invertebrates)	Whole body, flesh, honey, head, casts of slough, testis, fecal matter, blood, antler, urine, meat, intestine, droppings.	Arthritis, conjunctivitis, weakness, rickets, asthma, cough, pneumonia, urinary obstruction, hair loss, sex stimulant, wound, leprosy, male impotency, constipation, paralysis, earache, joint pain, fever, TB, ulcer, gout, burn, fracture.	Das (2015)

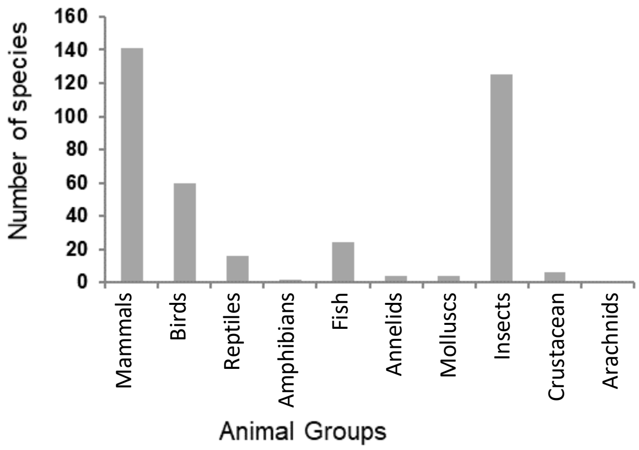

Figure 2. Type of animals used by different indigenous communities of Arunachal Pradesh, India

Arunachal Pradesh

Arunachal Pradesh is inhabited by 20 major indigenous communities (Dutta and Dutta 2005; Tynsong et al. 2020). These indigenous communities rely primarily on forest resources and follow activities such as collection of Non-Timber Forest Products (NTFPs), hunting, fishing, and animal trapping for their use in ethnomedicine and food (Solanki et al. 2004; Solanki and Chutia 2009).

Research by Solanki and Chutia (2009) stated that indigenous communities, namely Nyishi, Apatani, and Monpa, use approximately a total number of 100 animal species for their ethnomedicines; 48% of which belongs to mammalian species, 28% avian species and rest belong to amphibians and reptiles. For mammals, body parts such as skin, bones, fats, gall bladder, food pipe, reproductive organ and horns are used, whereas, in case of avian species, feathers and legs are predominantly used in traditional medicine formulations. Furthermore, the use of edible insects is also prevalent among the Galo community in ethnomedicine. Dagyom and Gopi (2009) reported a total of 12 edible insects along with four unidentified species that were used for ethno-zoological purposes by Galo tribes. A research carried out by Chakravorty et al. (2011a) reported that Nyishi and Galo communities use 81 species of edible and therapeutic insects and 36 vertebrate species for treating different ailments. Use of therapeutic insects and vertebrates by Nyishis and Galos has been found effective in curing ailments in domesticated cattle (Chakravorty et al. 2011b). Chinlampianga et al. (2013) estimate that Adi community use approximately 39 animal species (terrestrial and aquatic) in their conventional healthcare practice program. Bear, deer, ant's larvae, fish, porcupine tail, lizard, squirrel, hornbill, monkey, etc. are some of the species used by the Adi community. Usage of fish species viz., *Heteropneustes fossilis* and *Clarius batracus* and the use of insects with ant's larvae by females of Adi community have been reported to cure weak people and malaria sufferers (Chinlampianga et al. 2013). Monpa community uses about 11 animals (mammals and birds) for therapeutics as well as in many rituals of healing and religion (Solanki and Chutia 2004). The children of the Monpas are made to wear bear claws around their necks in their ancestral rituals as a belief in protecting them from evil spirits and performing the sacrifice of animals such as sheep, goats, etc., with a belief that satisfying their gods will alleviate suffering and promote healing (Solanki and Chutia 2004). Recent research by Jugli et al. (2019) recorded the use of 20 and 55 animal species among the ethnic groups of Wancho and Tangsa respectively, for therapeutics in humans and domesticated animals.

Figure 2 provides a graphic representation of the applications of animal classes by various indigenous communities of Arunachal Pradesh. The application of mammals, insects and birds is found to be the highest, while the application of other classes such as reptiles, amphibians, annelids, mollusks and crustaceans is seen to be less.

Assam

Assam is the second largest state in NE India and is home to a large number of cultural, natural as well as biological diversities (Borah and Prasad 2016). There have been numerous studies on the use of traditional plant-based medicine (Sajem and Gossai 2006; Saikia et al. 2006; Das et al. 2008; Sikdar and Dutta 2008), and mixed formulations using both plants and animals (Kalita et al. 2005; Betlu 2013) reported from the state. There are, however, very few reports on the use of animal-based medicines for treatment of ailments. Some studies relating to use of animals in traditional medicines are of Borah and Prasad (2016) on the application of 26 animal species to treat diseases like jaundice, asthma and pneumonia by local ethnic groups viz., Nath and Karbi; Borah and Prasad (2017) on extensive use of 44 species of animals for several ethno-zoological applications by indigenous communities like Ahom, Chutia, Koch-Rajbonshi, Kalita, and Tea tribes (Adivasis). Similarly, Hanse and Teron (2012), Teronpi et al. (2012), and Verma et al. (2014) also conducted a study among the Karbi community of the Karbi-Anglong District of Assam on the applicability of 14 species of animals, 14 species of ichthyofauna (fish), and 48 species of various animals respectively, for therapeutic purposes in the treatment of diseases such as piles, cancer, tuberculosis and eczema.

Analysis of reports from the state of Assam reveals that use of mammals is the highest, followed by fish, insects, birds, and reptiles (Figure 3). Application of other groups of animals like amphibians, annelids, mollusks, crustaceans and arachnids are least in use.

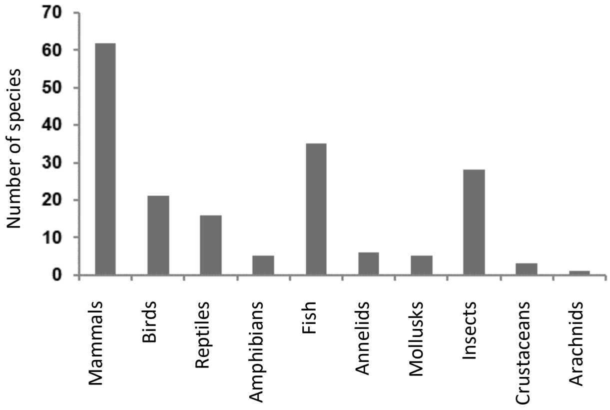

Figure 3. Type of animals used by different indigenous communities of Assam

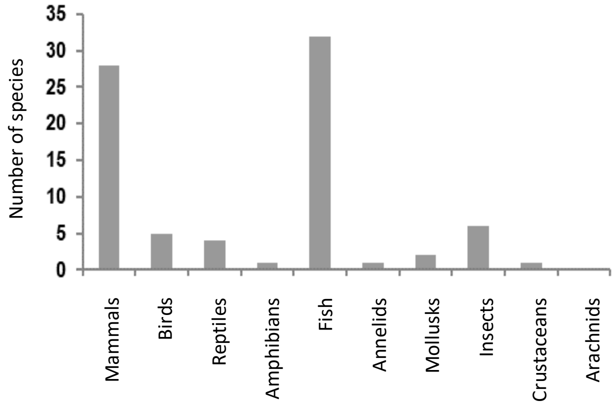

Figure 4. Type of animals used by different indigenous communities of Manipur

Manipur

Manipur is an oval-shaped valley state surrounded by hills (Devi et al. 2015). The State is known for its rich and varied natural resources, and is home to many native flora and fauna species (Chanu et al. 2016). Zootherapy among several groups in Manipur has been found to be an integral part of traditional folk healthcare practices (Devi et al. 2015). Indigenous communities of Manipur are accustomed to using a large number of animal species (wild and domesticated) in zoo-therapy procedures, the activities that involve both local and oral methods (Devi et al. 2015).

Research conducted by Chanu et al. (2016) recorded that the Meitei community had used some fish species as ethnomedicine. A total of 21 species of fish belonging to 11 families and 18 genera have been primarily used in the preparation of ethnomedicine by the Meitei community (Chanu et al. 2016). Fish are eaten raw, fried, or cooked for medicinal purposes, depending on the procedure prescribed/followed. Some of the most common fish species used by the Meitei community in ethnomedicine include *Aorichthys seenghala*, *Anguilla bengalensis*, *Barilius bendelisis*, *Catla catla*, *Channa orientalis*, *Channa striatus*, *Esomus danrica* and *Hilsha ilisha*. Meitei Folk Healers use liver, eye, bile, operculum, fish oil, barbels, and sometimes whole body of the fish (Chanu et al. 2016).

Another important study on animal-based ethnomedicine in Manipur had reported that a total of 33 animals are used in traditional zoo-therapy treatments by the traditional folk healers of Manipur; comprising of five invertebrates and 28 vertebrate species for treatment of 35 different ailments (Devi et al. 2015). It is stated that there are four different types of traditional zoo-therapies employed by Manipur's traditional folk healers, i.e., food, medicine, magico-religious, and faith healing, in which animals are either used completely or in parts depending on their needs. Similarly, Ngaomei and Singh (2016) reported that the Rongmei community of Manipur used a total of 26 animal species consisting of 14 mammals, 3 avian species, 3 reptiles, 2 amphibians, 1 mollusk, and 4 insect species to treat ailments such as rheumatic pain, typhoid and stomach disorders. The Rongmei community usually uses parts of the body such as flesh, bones, bone marrow, urine, bile, tongue, fat, stomach, hand, palms, hair, and whole body in traditional medicine formulations.

It is observed that application of fish species in traditional medicines is highly prevalent in Manipur, followed by the use of mammals, insects, birds and reptiles (Figure 4). Use of amphibians, annelids, mollusks, and crustaceans is also prevalent.

Meghalaya

In Meghalaya, indigenous communities have existed in profound and intense communion with nature from time immemorial (Mihsill and Keshan 2017). The Khasi, Jaintia, and Garo are the three primary indigenous communities in Meghalaya, which together constitute 86% of the overall population of the state (Tiwari et al. 2010). There have been numerous studies on the use of traditional plant-based medicine (Laloo et al. 2006; Tynsong et al. 2006; Sawian et al. 2007; Hynniewta and Kumar 2008) while reports on the use of traditional medicine based on animals in Meghalaya are extremely limited. Research conducted by Turnia and Prasad (2017) confirmed that the Khasi community used 13 animal-based medicine to treat ailments such as asthma, anemia, diarrhea and regular cough, cold and fever. Mihsill and Keshan (2017) documented the use of animals and animal products in traditional cure practices by the Khasis. Mihsill and Keshan (2017) reported that Khasi community believe that malaria can be cured by consuming hill mole (known as 'kyndat lyndang' in Khasi dialect) or cow bile, tigress milk mixed with mud in healing burns; sun-dried deer fetus to cure 'suhsynria' in khasi dialect (a condition of disease prevalent in breastfeeding mothers), use of catfish (*Channa striatus*) to treat a condition similar to leukoderma in infants and use of leeches to suck blood from pus boils.

It is observed that in Meghalaya, mammals are mainly used in traditional medicine followed by insects. However, use of other animal groups like birds, amphibians, mollusks, crustaceans, etc., for zoo-therapeutic applications is not reported (Figure 5).

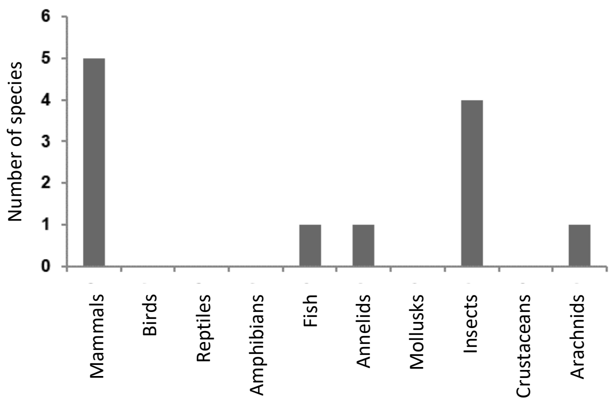

Figure 5. Type of animals used by different indigenous communities of Meghalaya

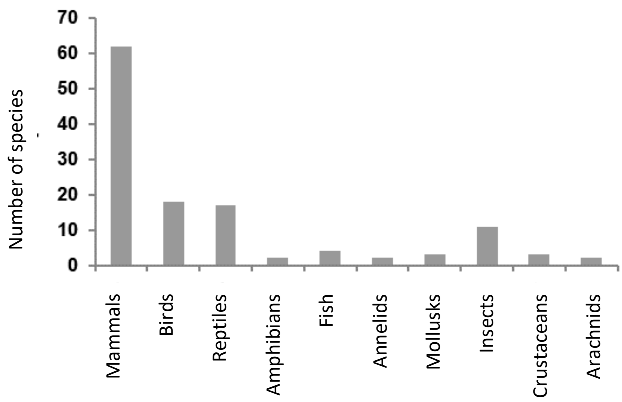

Figure 6. Type of animals used by different indigenous communities of Mizoram

Mizoram

Mizoram is a hilly state located in the lower corner of the NE region, traversing many ranges of hill slopes; and less scattered plains and is inhabited primarily by two distinct indigenous communities i.e., Chakma and Mara; besides other communities such as Lai, Paite, and Hmar (Chinlampianga et al. 2013). Traditional health care systems using animals were well defined and documented in Mizoram (Harit 2001). Mizoram's ground-breaking research on ethno-zoological traditional medicine emphasized the use of at least ten animal species for the treatment of asthma and respiratory disorders, including reports for multiple ailments of a total of 56 animal species (Lalramnghinglova 1999). A study conducted by Chinlampianga et al. (2013) in the Zomi-Paite community revealed that a total of 48 species of fauna consisting of mammals, birds, reptiles, arthropods, amphibians, annelids, insects, and fish are used for diseases like asthma, arthritis, leprosy, malaria, wound, respiratory, kidney, gynecological, cholera, tuberculosis, diabetes, hypertension, and jaundice. Animal body parts or organs used for the practice of ethnomedicine include fat, feather, hair, bile, blood, meat, bone, skin, milk, and liver; either in cooked/boiled/roasted form (Chinlampianga et al. 2013). Solanki et al. (2016) stated that the Mizo, Bru, and Chakma communities used animals for medicinal applications and approximately nine mammalian species, three reptiles, and one bird species have been commonly used for medicinal purposes, mainly utilizing body parts such as gall bladder, bones, brain, blood, hair, skin, nails, liver, stomach, and intestines.

Existing literature on zoo-therapeutic applications in Mizoram shows that use of mammals had been the largest, followed by use of birds, reptiles and insects. Applications of other animal groups such as amphibians, reptiles, annelids, mollusks, crustaceans, and arachnids are also prevalent but at comparatively smaller frequencies (Figure 6).

Nagaland

Nagaland state borders Arunachal Pradesh, Assam, and Manipur; and is made up of plains and hilly regions. Nagaland is inhabited by several indigenous communities like Ao, Angami, Lotha, Phom, Chang, Sangtam, Chakhesang, Zeliang, Rengma, Yumchunger, Khiamniungan, Konyak, Sema, Pochury and various sub-groups (Zhimomi 2004). Research conducted by Jamir and Lal (2005) on ethnozoological knowledge reported a total of 26 animal species used by 11 indigenous communities in Nagaland for zoo-therapeutic remedies. Cat, deer, bear, dog, elephant, goat, flying squirrel, jackal, monkey, frog, python, cobra, crow, pheasant, pigeon, peacock, earthworm, apple snail, cockroach, crab, scorpion and eel are some of the animals used for traditional medicine. Organ/body parts used for medical practice include whole meat, gall bladder; extracts from the bile ducts, fresh blood, and whole body consumed raw/cooked, skin and male organ.

Kakati and Doulo (2002) recorded animal use in traditional medicines among the Chakhesang community of Nagaland, which employed 23 animal species. Among the Ao community, comprehensive research on ethnozoological knowledge was conducted by Kakati et al. (2006), who recorded that people relied on zoo-therapeutic medicines to treat diseases such as body pain, rheumatism, asthma, liver disorders, tuberculosis, night blindness, bone fractures, malaria, dysentery, kidney problems, and respiratory disease. Kakati et al. (2006) recorded that a total of 25 different species of vertebrates are used by Ao community which include mammals, aves, reptiles, amphibians, and fish. Traditional healers of Ao community use body parts like fats, meat, bile, teeth, intestine, urine, liver, legs, milk, blood, bones, and skin.

It is noted that indigenous communities of Nagaland primarily use mammals in their traditional medicine accompanied in their various formulations, followed by birds, reptiles, amphibians and insects. Other animal groups such as fish, annelids, mollusks, crustaceans, and arachnids also find their uses in traditional medicine of Nagaland (Figure 7).

Sikkim

Sikkim is located in the foothills of the Himalayas, inhabited by indigenous communities like Lepcha, Bhutia and Nepali following diverse cultures and traditions (Dhakal et al. 2019). Literature survey on the use of traditional medicine in Sikkim revealed that the state relies heavily on the state's flora, which has a rich and large range of natural resources (Dhakal et al. 2019). Knowledge regarding the use of faunal medicine as part of traditional folklore is fairly scanty and fragmentary. Dhakal et al. (2019) conducted a comprehensive survey of traditional communities and reported that males of such communities were dominant in traditional medicine usage compared to females; and are mostly people with lower annual incomes and practice as a part-time livelihood. Dhakal et al. (2019) recorded that 59 animal species were used in ethno-zoological practices, 71% of which were used in zootherapy, while the remaining 39% were recorded to be used in various religious or shamanic activities. Of the 59 animals, 34 were mammals, 13 bird species, and rest consisted of insects, amphibians, reptiles, mollusks, etc.; suggesting mammals as the dominant group used in traditional medicine (Figure 8).

Tripura

Tripura is a small hilly state, inhabited by 19 indigenous communities (Das 2015). Studies on traditional medicine using flora and fauna are extremely limited in Tripura, with few recorded studies on the use of ethnomedicinal plants (Das et al. 2009; Sen et al. 2011; Sharma et al. 2014; Debbarma et al. 2017), and scarce details on the use of ethnomedicine based on animals. A study on use of ethnomedicine based on animals by Das (2015) provided a detailed report on the applications of ethnozoological medicine practiced by the Tripuri, Jamatia, and Reang communities of Tripura. Das (2015) recorded the use of 25 animal species being used for the treatment of asthma, paralysis, cough, fever and wound healing. Many animals used in ethnomedicine include goat (for tuberculosis, ulcer and gout treatment), apple snail (conjunctivitis and rickets), pigs (fractures, burns and wounds), while animals such as cows and fish have been documented to be in lesser uses as compared to other animals (Das 2015). Existing literature on zoo-therapeutic applications in Tripura reveals that use of mammals is the highest, followed by use of insects, birds, crustaceans, and fish (Figure 9).

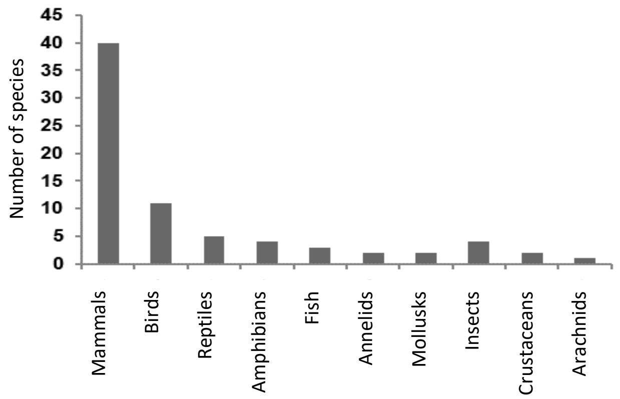

Figure 7. Type of animals used by different indigenous communities of Nagaland

Animals used in the treatment of various diseases

Based on our comprehensive literature survey, we could assess that malaria, tuberculosis, wounds, cough and cold, burns, dysentery, jaundice, stomach disorders, rheumatism, asthma, liver problems, joint pain, fever, fatigue, women's issues, fractures, animal/insect bites, anemia, male impotence and diabetes are the 20 most common diseases which are reported to be cured with the application of ethno-zoological medicines. Details of the types of animals used to treat these diseases and the indigenous communities involved are provided in Table 3.

In the ethnozoological applications among communities of NE India, mammals, fish, reptiles, annelids, amphibians, mollusks, insects, birds, crustaceans, mollusks, arachnids, etc., are widely used species types. Analysis of the IUCN Red List of Endangered Species (IUCN 2020) shows that 58 species are classified as Least Concern (LC), 21 species are classified as Vulnerable (VU), 9 species are classified as Endangered (EN), 7 species are classified as Near Threatened (NT), 3 species are classified as Critically Endangered (CR), 1 species is classified as Data Deficient (DD). Conservation status of these animal species as per IUCN (2020) is provided in Table 4.

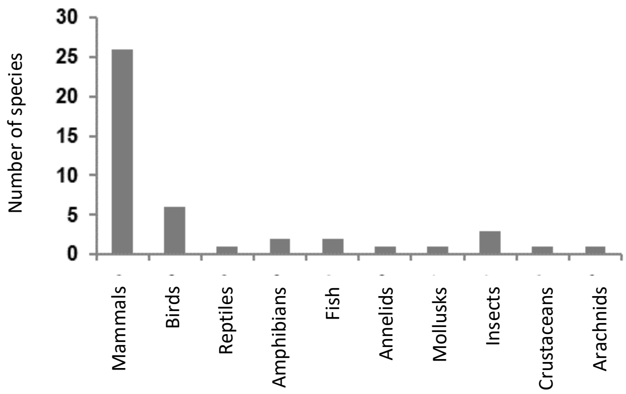

Figure 8. Type of animals used by different indigenous communities of Sikkim

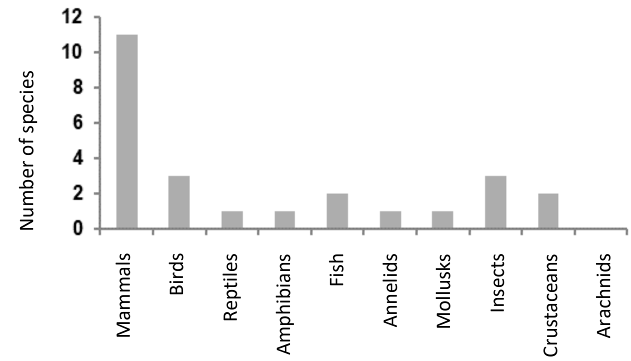

Figure 9. Type of animals used by different indigenous communities of Tripura

Table 3. Details and number of animals used in the ethno-zoological treatment 20 most common ailments/diseases

Disease	Animals used	Indigenous communities and their state	Literature
Malaria (37 species)	*Channa punctatus* (Snake head fish), *Anabus testudineus* (Fish), *Solenopsis* sp. (Red ant), *Aspongopus najus* (Tari insect), *Cimex lactularis* (Bed bug), *Hystrix indica* (Indian porcupine), *Maccaca assamensis* (Assamese Macaque), *Pheritima* sp. (Earthworm), *Tehanochelys trijuga* (Turtle), *Varanus bengalensis* (Monitor Lizard), *Viper ruselli* (Viper), *Haliaeetus* sp. (Eagle), *Dicrurus* sp. (Drongo), *Buceros bicornis* (Great Hornbill), *Megalaima* sp. (Barbet), *Panthera tigris* (Tiger), *Manis* sp. (Pangolin), *Pteropus* sp. (Flying fox), *Chiroptera* sp. (Bat), *Bothroponera rufipes* (Black ant), *Moschus* sp. (Musk Deer), *Ursus thibetanus* (Black bear), *Panthera pardus* (Leopard), *Trachypithecus pileatus* (Capped langur), *Macaca mulatta* (Rhesus monkey), *Bunopithecus hoollock* (Hoolock gibbon), *Corvus culminatus* (Jungle Crow), *Bos* sp. (Mithun), *Vulpes bengalensis* (Fox), *Testudo* sp. (Tortoise), *Mastacembelus armatus* (Spiny eel), *Canis aureus* (Golden jackal), *Nycticebus coucang* (Slow loris), *Talpa* sp. (Hill mole), *Python molurus* (Python), *Cancer pararus* (Crab) and *Felis silvestris* (Wild cat).	Adi, Apatani, Galo, Monpa, Nyishi, Tangsa and Wancho of Arunachal Pradesh; Biate and Karbi of Assam; Rongmei and other groups of Manipur; Khasis of Meghalaya; Mizo, Bru and Chakma of Mizoram; Ao and Chakhesang of Nagaland; Lepcha, Bhutia and Nepali of Sikkim.	Solanki and Chutia (2004); Kakati et al. (2006); Chakravorty et al. (2011 a); Chinlampianga et al. (2013); Betlu (2013); Verma et al. (2014); Devi et al. (2015); Ngaomei and Singh (2016); Solanki et al. (2016); Mihsill and Keshan (2017); Dhakal et al. (2019); Jugli et al. (2019).
Tuberculosis (21 species)	*Pila globusa* (Apple Snail), *Periplaneta americana* (Cockroach), *Moschus moschiferus* (Musk deer), *Talpa* sp. (Mole), *Vulpes bengalensis* (Fox), *Hystrix* sp. (Porcupine), *Selenarctos thibetanus* (Himalayan black bear), *Macaca assamensis* (Assamese macaque), *Hoolock leuconedys* (Eastern Hoolock Gibbon), *Python molurus* (Indian python), *Amphipnous cuchia* (Cuchia), *Capra hircus* (Goat), *Manis crassicaudata* (Indian pangolin), *Channa punctatus* (Spotted snakehead fish), *Tachypodoiulus niger* (Black millipede), *Canis familiaris* (Dog), *Macaca mulatta* (Rhesus monkey), *Naurey musa* (Mongoose), *Scylla* sp. (Mud crabs), *Eutropiichthys vacha* (Fish) and *Canis aureus* (Wild fox).	Apatani, Nyishi, Monpa, Galo and Tangsa of Arunachal Pradesh; Karbi, Biate and Nath of Assam; Meitei, Pangals, Chothe, Kabui, Kom (Moirang-maninghao), Rongmei and others of Manipur; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim; Tripuri, Jamatia and Reang of Tripura.	Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Chakravorty et al. (2011b); Hanse and Teron (2012); Betlu (2013); Verma et al. (2014); Das (2015); Devi et al. (2015); Borah and Prasad (2016); Chanu et al. (2016); Ngaomei and Singh (2016); Dhakal et al. (2019); Jugli et al. (2019).

Wounds (33 species)	*Mastacembelus armatus* (Eel fish), *Chaca chaca* (Fish), *Python molurus* (Python), *Naja naja* (Cobra), *Spizaetus* sp. (Eagle), *Dicrurus* sp. (Drongo), *Strigiformes* sp. (Owl), *Buceros* sp. (Hornbill), *Megalaima* sp. (Barbet), *Panthera tigris*, *Bos frontalis*, *Hystrix brachyuran* (Porcupine), *Ursus thibetanus* (Himalayan Black Bear), *Manis* sp. (Pangolin), *Pteropus* sp. (Flying fox), *Chiroptera* sp. (Bat), *Bothroponera rufipes*, *Amblyceps* sp. (Fish), *Rana* sp. (Frog), *Panthera pardus*, *Mantis religiosa* (Praying mantis), *Clarias batrachus* (Magur fish), *Heteropneustes fossilis* (Singing catfish), Human urine, *Caurausius* sp. (Stick insect), *Araneae* sp. (Spiders), *Canis aureus* (Jackal), *Sus scrofa* (Pig), *Lepus nigricollis* (Indian Hare), *Tetragonula iridipennis* (Stingless bee), *Rucervus unicolor* (Sambar Deer), *Rhizomys sumatrensi* (Bamboo rat) and *Pila* sp. (Snail).	Apatani, Nyishi, Monpa, and Galo of Arunachal Pradesh; Ahom, Chutia, Koch-Rajbonshi, Kalita and Adivasis and Karbis of Assam; Rongmei and other groups of Manipur; Khasi of Meghalaya; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim; Tripuri, Jamatia and Reang of Tripura.	Kakati and Doulo (2002); Kakati et al. (2006); Solanki and Chutia (2009); Chakravorty et al. (2011a); Teronpi et al. (2012); Verma et al. (2014); Das (2015); Ngaomei and Singh (2016); Borah and Prasad (2017); Mihsill and Keshan (2017); Dhakal et al. (2019).
Cough and cold (31 species)	*Apis* sp. (Honey bee), *Polistes* sp. (Wasp), *Vespa orientalis* (Potter wasp), *Melursus ursinus* (*Sloth* bear), *Moschus* sp., *Ursus thibetanus* (Asiatic Black Bear), *Anthracoceros albirostris* (Pied hornbill), *Python molurus*, *Cynopterus sphinx* (Bat), *Macrocheraia* sp. (Giant red bug), *Puntius sp.* (Fish), *Equus asinus* (Donkey), *Sciurus caroliniensis* (Squirrel), *Mus musculus* (House mouse), *Periplaneta americana*, *Calotes versicolor* (Common garn lizard), *Canis aureus*, *Helarctos malayanus* (Malayan sun bear), *Buceros* sp. (Great hornbill), *Corvus* sp. (Jungle crow), *Hystrix* sp., *Lepus nigricollis*, *Bos* sp. (Cattle), *Sus domesticus* (Pig), *Nanorana liebigii* (Frog), *Tetragonula iridipennis*, *Capra aegagrus* (Goat), *Felis silvestris*, *Macaca* sp. (Monkey), *Cancer pararus* (Crab), and *Podisus* sp. (Plant bug).	Nyishi, Galo, Apatani, Monpa, Tangsa and Wancho of Arunachal Pradesh; Nath and Karbi of Assam; Rongmei and other groups of Manipur; Khasi of Meghalaya; Mizo, Bru and Chakma of Mizoram; Chakhesang of Nagaland; Lepcha, Bhutia and Nepali of Sikkim; Tripuri, Jamatia and Reang of Tripura.	Lalramnghinglova (1999); Kakati and Doulo (2002); Solanki et al. (2004); Teronpi et al. (2012); Verma et al. (2014); Das (2015); Devi et al. (2015); Borah and Prasad (2016); Ngaomei and Singh (2016); Mihsill and Keshan (2017); Jugli et al. (2019); Dhakal et al. (2019).
Burns (30 species)	*Anguilla* sp. (Eel), *Bagarius* sp. (Gangetic goonch), *Amblyceps* sp. (Catfish), *Spilornis cheela* (Eagle), *Ursus thibetanus*, *Melursus ursinus*, *Panthera tigris*, *Neofelis nebulosa* (Clouded leopard), *Pteromys* sp. (Flying Squirrel), *Capra* sp., *Nycticebus* sp. (Slow loris), Human urine, *Buceros* sp., *Gallus domesticus* (Chicken), *M. armatus* (Spiny eel fish), *Python reticulates* (Reticulated python), *Sartoriana* sp. (Red freshwater crab), *Varanus bengalensis*, *Gallus* sp. (Jungle Fowl), *Lutrogale perspicillata* (Smooth-coated otter), *Metaphire houletti* (Earthworm), *Apis* sp. *Canis* sp. (Dog), *Manis* sp., *Sus scrofa* (Pig), *Ovis aries* (Sheep), *Lymnonecties* sp. (Frog), *Cervus* sp. (Deer), *Hystrix* sp., and *Pila* sp. (Snail).	Nyishi, Galo, Tangsa and Wancho of Arunachal Pradesh; Biate, Nath and Karbi of Assam; Rongmei, of Manipur; Khasi of Meghalaya; Mizo, Bru and Chakma of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim; Tripuri, Jamatia and Reang of Tripura.	Kakati and Doulo (2002); Jamir and Lal (2005); Kakati et al. (2006); Chakravorty et al. (2011b); Betlu (2013); Das (2015); Borah and Prasad (2016); Ngaomei and Singh (2016); Solanki et al. (2016); Mihsill and Keshan (2017); Dhakal et al. (2019); Jugli et al. (2019).

Dysentery (32 species)	*Acheta* sp. (Cricket), *Dinocras cephalotes* (Stone fly), *Ephemera dancia* (May fly), *Philopotamus montanus* (Caddis fly), *Musca domestica* (Housefly), *Gallus gallus*, *Dicrurus* sp. (Drongo), *Tyto alba* (Brown owl), *Buceros* sp. (Hornbill), *Megalaima* sp. (Barbet), *Panthera tigris*, *Moschus moschiferus* (Musk deer), *Macaca assamensis*, *Trachypithichus pileatus* (Capped langur), *Bunopithicus hoolock* (Hoolock gibbon), *Ursus thibetanus* (Himalayan Black Bear), *Manis* sp. (Pangolin), *Pteropus giganteus* (Flying fox), *Cynopterus sphinx* (Bat), *Bothroponera rufipes* (Black ant), *Oecophylla smaragdina* (Red tree ant), *Hystrix* sp., *Panthera pardus*, *Python* sp., *Cervus* sp. (Musk Deer), *Bos indicus* (Cow), *Channa gachua* (Fish), *Varanus bengalensis*, *Pseudois nayaur* (Himalayan blue sheep), *Hemitragus jemlahicus* (Himalayan Tahr), *Mystus bleekeri* (Fish), and *Nanorana liebigii* (Frog).	Apatani, Nyishi, Galo and Monpa of Arunachal Pradesh; Ahom, Chutia, Koch-Rajbonshi, Kalita, Adivasis, Nath, Karbi and Dimasa of Assam; Meitei, Meitei Pangals, Chothe (Lamlanghupi), Kabui (Nambol), Kom (Moirang-maninghao) of Manipur; Mizo, Bru and Chakma of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim;	Kakati and Doulo (2002); Jamir and Lal (2005); Kakati et al. (2006); Chakravorty et al. (2011a); Chakravorty et al. (2011b); Teronpi et al. (2012); Verma et al. (2014); Borah and Prasad (2016); Chanu et al. (2016); Solanki et al. (2017); Dhakal et al. (2019).
Jaundice (24 species)	*Capricornis sumtraensis* (Serow), *Naemorhedus goral* (Himalayan Goral), *Pseudois nayaur* (Bharal), *Budorcas taxicolor* (Takin), *Macaca assamensis Trachypithichus pileatus*, *Bunopithicus hoolock*, *Ursus thibetanus*, *Manis pentadactyla*, *Pteropus giganteus* (Flying fox), *Cynopterus sphinx* (Bat), *Panthera tigris*, *Melursus ursinus*, *Hystrix* sp., *Varanus bengalensis*, *Rhinoceros unicornis* (one-horned Rhino), *Bos indicus* (Cow), *Amphipnous cuchia* (Eel), *Ovis aries* (Sheep), *Corvus macrorhynchos* (Jungle crow), *Lymnaea* sp. (Water snail), *Xestina* sp. (Land snail), *Capra* sp., and *Cancer pararus* (Crab).	Apatani, Nyishi, Galo, Monpa and Tangsa of Arunachal Pradesh; Nath, Karbi and Biate of Assam; Mizo of Mizoram; Ethnic groups of Manipur; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Hanse and Teron (2012); Betlu (2013); Verma et al. (2014); Devi et al. (2015); Jugli et al. (2019).
Stomach ailments (29 species)	*Pila* sp., *Cancer pararus*, *Polistes herbraeus* (Wasp), *Dinocras cephalotes* (Stone fly), *Ephemera dancia* (May fly), *Philopotamus montanus* (Caddis fly), *Varanus bengalensis*, *Geoemyda mouhati* (Tortoise), *Ursus thibetanus*, *Manis* sp., *Apis* sp., *Oecophylla smaragdina* (Red tree ant), *Semiplotus* sp., (Fish), *Labeo rohita*, *Bagarius* sp., *Corvus splendens*, *Capra* sp., *Moschus* sp., *Melursus ursinus*, *Python molursus*, *Geochelone emys* (Eastern hill tortoise), *Hoolock hoolock*, *Macaca* sp., *Antilocapra americana* (Antelope), *Hystrix* sp., *Callosciurus* (Oriental tree squirrel), *Archispirostreptus gigas* (Millipede), Human urine and *Sus crisatus* (Wild boar).	Apatani, Nyishi, Galo, Monpa, Tangsa and Wancho of Arunachal Pradesh; Karbi and Dimasa of Assam; Rongmei of Manipur; Mizo, Bru and Chakma of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Hanse and Teron (2012); Teronpi et al. (2012); Devi et al. (2015); Ngaomei and Singh, (2016); Solanki et al. (2016); Jugli et al. (2019).

Rheumatism (33 species)	*Varanus bengalensis*, *Naja naja* (Cobra), *Haliaeetus* sp. (Eagle), *Megalaima* sp. (Barbet), *Pardofelis* sp. (Marbled cat), *Civettictis* sp. (Civet), *Martes flavigula* (Yellow-throated marten), *Mustela* sp. (Weasel), *Herpestes* sp. (Mongoose), *Lutrinae* sp. (Otter), *Moschus moschiferus*, *Hystrix brachyuran*, *Panthera tigris*, *Panthera paradus*, *Cervulus muntjac* (Barking deer), *Cryptozona* sp. (Snail), *Hoolock hoolock*, *Puntius* sp. (Fish), *Crotalus durissus* (Neotropical rattle snake), *Dusicyon* sp. (Fox), *Ovis aries*, *Arctonyx collaris* (Hog badger), *Buceros* sp. (Wheated hornbill), *Bagarius* sp., *Sus scrofa*, *Anguilla bengalensis*, *Salenarctos* sp., *Palamnaeus swammerdami* (Scorpion), *Python reticulates*, *Lymnonecties limnorcharis* (Frog), *Centropus sinensis* (Greater Coucal), *Bubalus arnee* (Wild water Buffalo), and *Corvus splendens*.	Apatani, Nyishi, Monpa of Arunachal Pradesh; Karbi and Biate of Assam; Ethnic groups of Manipur; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Hanse and Teron (2012); Teronpi et al. (2012); Betlu (2013); Verma et al. (2014); Devi et al. (2015); Dhakal et al. (2019).
Asthma (37 species)	*Pila* sp., *Periplaneta americana*, *Acheta* sp., *Mastacembelus armatus*, *Monopterus cuchia* (Eel fish), *Varanus bengalensis*, *Geoemyda mouhati* (Tortoise), *Capricornis sumtraensis* (Serow), *Naemorhedus goral* (Goral), *Pseudois nayaur*, *Budorcas taxicolor*, *Hoolock leuconedys*, *Anthracoceros albirostris* (Pied hornbill), *Cynopterus* sp. (Bat), *Polypedates leucomystax* (Common tree frog), *Amblypharyngodon mola* (Indian carplet fish), *Chaca chaca*, *Herpestes edwardsii*, *Sciurus caroliniensis* (Squirrel), *Apis* sp., *Pseudacanthotermes* sp. (Termite), *Talpa* sp., *Bos gaurus* (Indian Bison), *Calotes versicolor*, *Canis familiaris*, *Centropus sinensis*, *Hystrix indica*, *Picus canus* (Black napped green woodpecker), *Viverricula indica* (Small Indian Civet), *Carcinus* sp., *Pteropus* sp. (Flying fox), *Ursus thibetanus*, *Lumbricus* sp. (Earthworm), *Capra* sp., *Petaurista petaurista* (Red Giant Flying squirrel), *Gallus sonnerati* (Jungle fowl), and *Columba livia* (Pigeon).	Apatani, Nyishi, Monpa, Tangsa and Wancho of Arunachal Pradesh; Ahom, Chutia, Koch-Rajbonshi, Kalita and Adivasis, Nath and Karbi of Assam; Ethnic groups of Manipur; Mizo, Bru and Chakma of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim; Tripuri, Jamatia and Reang of Tripura.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Verma et al. (2014); Das (2015); Devi et al. (2015); Borah and Prasad (2017); Dhakal et al. (2019); Jugli et al. (2019).
Liver ailments (14 species)	*Vulpes bengalensis* (Fox), *Rhizomys pruinosus* (Hoary bamboo rat), *Hystrix* sp., *Cynopterus sphinx* (Bat), *Hoolock leuconedys* (Hoolock gibbon), *Bos indicus* (Cow), *Wallago attu* (Fish), *Cancer* sp. (Crab), *Lymnaea* sp. (Water snail), *Melursus ursinus* (Sloth bear), *Rhinoceros unicornis* (One-horned Rhino), *Ursus thibetanus*, *Capra* sp., and *Felis* sp. (Wild cat).	Nyishi, Tangsa of AP; Nath and Karbi of Assam; Ethnic groups of Manipur; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim.	Solanki et al. (2004); Jamir and Lal (2005); Kakati et al. (2006); Hanse and Teron (2012); Teronpi et al. (2012); Devi et al. (2015); Borah and Prasad (2016); Dhakal et al. (2019); Jugli et al. (2019).

Joint pain (13 species)	*Bagarius* sp., *Python molurus*, *Ursus thibetanus* (Asiatic Black Bear), *Pteropus medius* (Flying fox), *Canis aureus*, *Capricornis sumatraensis* (Mainland serow), *Sus scrofa domesticus* (Pig), *Xenentodon cancila* (Freshwater gar fish), *Echis coloratus* (Viper), *Struthio camelus* (Common Ostrich), *Macaca mullata* (Rhesus macaque), *Buceros bicornis* (Hornbill), and *Apis dorsata* (Giant bee).	Nyishi, Galo, and Tangsa of Arunachal Pradesh; Karbi, Biate, Nath of Assam; Mizo of Mizoram; Tripuri, Jamatia and Reang of Tripura; Lepcha, Bhutia and Nepali of Sikkim; Rongmei Manipur.	Hanse and Teron (2012); Betlu (2013); Verma et al. (2014); Das (2015); Borah and Prasad (2016); Ngaomei and Singh (2016); Dhakal et al. (2019); Jugli et al. (2019).
Fever (21 species)	*Apis* sp., *Oecophylla smaragdina*, *Selenarctos thibetanus*, *Bunopithecus hoollock*, *Cynopterus sphinx* (Bat), *Maydelliathelphusa lugubris* (Fresh water crab), *Canis familiaris* (Dog), *Vulpes* sp., *Leptocorisa varicornis* (Rice bug insect), *Hystrix indica*, *Cyprinus carpio* (Common carp), *Bos indicus* (Cow), *Manis pentadactyla* (Chinese pangolin), *Bandicota* sp. (Mole), *Herpestes* sp. (Mongoose), *Corvus macrorhynchos* (Large billed crow), *Aorichthys seenghala* (Fish), *Mastacembelus armatus*, *Cervus* sp. (Deer), *Trachypithecus pileatus*, and *Macaca assamensis*.	Nyishi, Galo, Monpa and Tangsa of AP; Karbi, Ahom, Chutia, Koch-Rajbonshi, Kalita and Adivasis of Assam; Mizo of Mizoram; Tripuri, Jamatia and Reang of Tripura; Lepcha, Bhutia and Nepali of Sikkim; Meitei, Meitei Pangals, Chothe, Kabui, Kom of Manipur; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Solanki et al. (2004); Jamir and Lal (2005); Hanse and Teron (2012); Das (2015); Chanu et al. (2016); Borah and Prasad (2017); Dhakal et al. (2019); Jugli et al. (2019).
Weakness (27 species)	*Cervus unicolor* (Sambar), *Macaca assamensis*, *Monopterus cuchia*, *Axis porcinus* (Hog deer), *Bos grunniens* (Yak), *Moschus moschiferus* (Musk deer), *Capricornis sumtraensis*, *Naemorhedus goral*, *Pseudois nayaur*, *Budorcas taxicolor*, *Bos frontalis*, *Vulpes bengalensis* (Fox), *Hoolock leuconedys*, *Columba livia*, *Monopterus* sp., *M. armatus* (Spiny eel fish), *Clarias batrachus* (Walking catfish), *Python molurus*, *Palaemon* sp. (Prawn), *Prionailurus bengalensis* (Leopard cat), *Columba* sp., *Capra* sp., *Wallago attu* (Cat Fish), *Selenarctos* sp., *Varanus bengalensis*, *Civettiictis civetta* (Civet), and *Haliaeetus* sp. (Eagle).	Apatani, Nyishi, Monpa, Tangsa, Wancho of AP; Mizo of Mizoram; Tripuri, Jamatia and Reang of Tripura; Ethnic groups of Manipur; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Chinlampianga et al. (2013); Das (2015); Devi et al. (2015); Jugli et al. (2019).
Female problems (23 species)	*Chiroptera* sp. (Bat), *Hystrix indica*, *Python molursus*, *Macaca assamensis*, *Rhyticeros undulatus ticehursti* (Wheathead hornbill), *Hylobates hoolock*, *Bos frontalis* (Mithun), *Capra hircus*, *Rattus sp.* (Rat), *Vulpes bengalensis* (Fox), *M. armatus* (Spiny eel fish), *Ursus thibetanus*, *Canis lupus familiaris* (Dog), *Platanista gangetica* (River dolphin), *Monopterus cuchia* (Cuchia fish), *Clarias batrachus* (Magur fish), *Heteropneustes fossilis* (Fish), *Labeo pangusia* (Fish), *Lepus capensis* (Rabbit), *Luthra perspicillata perspicillata* (Otter), *Colisa sota* (Fish), *Manis crassicaudata*, and *Cervus/Machus* sp. (Deer).	Adi, Apatani, Nyishi, Monpa, Galo, Tangsa, Wancho of AP; Biate, Nath, Karbi and Dimasa of Assam; Meitei, Meitei Pangals, Chothe (Lamlanghupi), Kabui (Nambol) Kom communities; Rongmei of Manipur; Mizo, Bru, Chakma of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Lalramnghinglova (1999); Kakati and Doulo (2002); Jamir and Lal (2005); Solanki et al. (2005, 2016); Teronpi et al. (2012); Chinlampianga et al. (2013); Betlu (2013); Verma et al. (2014); Devi et al. (2015); Borah and Prasad (2016); Chanu et al. (2016); Ngaomei and Singh (2016); Jugli et al. (2019).

Fractures (11 species)	*M. ursinus* (Sloth Bear), *Pila* sp., *Gallus domesticus* (Chicken), *Hylobates hoolock*, *Xestina* sp., *Sus scrofa domestica*, *Hemitragus jemlahicus*, *Naja* sp. (Cobra), *Hystrix* sp., *Capra sibirica*, and *Aquila rapax* (Eagle).	Nyishi of AP; Ahom, Chutia, Koch-Rajbonshi, Kalita, Adivasis, Nath and Karbi of Assam; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Pochury, Lotha, Khiamniungan, Yimchunger, Chakhesang, Zeliang, and Rengma of Nagaland; Tripuri, Lepcha, Bhutia and Nepali of Sikkim; Jamatia and Reang of Tripura.	Lalramnghinglova (1999); Kakati and Doulo (2002); Solanki et al. (2004); Jamir and Lal (2005); Kakati et al. (2006); Das (2015); Borah and Prasad (2017); Dhakal et al. (2019).
Animal/insect bites (14 species)	*Apis* sp., *Python molurus*, *Hystrix brachyuran*, *Canis lupus familiaris* (Dog), *Viverra zibetha* (Large Indian civet), *Vespa orientalis* (Oriental hornet), *Maydelliathelphusa lugubris* (Freshwater crab), *Eutropis carinata* (Common Indian skink), *Capra hircus*, *Bufo melanostictus* (Toad), *Hylobates hoolock*, *Pheretima* sp. (Earthworm), *Varanus bengalensis*, and *Sus* sp. (Pig).	Apatani, Nyishi, Monpa, Tangsa of Arunachal Pradesh; Biate, Ahom, Chutia, Koch-Rajbonshi, Kalita and Adivasis of Assam; Ethnic groups of Manipur; Mizo Mizoram; Ao, Angami, Sema, Sangtam, Lotha, Khiamniungan, Yimchunger, Zeliang, Chakhesang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Betlu (2013); Devi et al. (2015); Borah and Prasad (2017); Dhakal et al. (2019); Jugli et al. (2019).
Anemia (6 species)	*Monopterus cuchia* (Eel Fish), *Bos indicus*, *Hylobates hoolock*, *Clarias batrachus*, *Heteropneustes fossilis* (Catfish), and *Maschus* sp. (Musk Deer).	Karbi of Assam; Meitei, Pangals, Chothe, Kabui, Kom of Manipur; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Lalramnghinglova (1999); Kakati and Doulo (2002); Jamir and Lal (2005); Teronpi et al. (2012); Verma et al. (2014); Devi et al. (2015); Chanu et al. (2016).
Male impotency (15 species)	*Muntiacus muntjak* (Barking deer), *Bos grunniens* (Yak), *Budorcas taxicolor*, *Bos frontalis*, *Capricornis sumatraensis* (Serow), *Naemorhedus goral* (Goral), *Pseudois nayaur*, *Gekko gecko* (Tokay gecko), *Passer domesticus* (House sparrow), *Cryptozona bistrialis* (Snail), *Gallus gallus*, *Myotis lucifugus* (Bat), *Canis familiaris*, *Herpestes* sp., and *Aquila* sp.	Apatani, Nyishi and Monpa of AP; Biate, Ahom, Chutia, Koch-Rajbonshi, Kalita and Adivasis of Assam; Rongmei of Manipur; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, and Rengma of Nagaland; Tripuri, Jamatia and Reang of Tripura.	Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Betlu (2013); Das (2015); Ngaomei and Singh (2016); Borah and Prasad (2017).
Diabetes (17 species)	*Penaeus indicus* (Prawn), *Puntius* sp., *Scylla serrata* (Crab), *Bufo melanostictus* (Toad), *Tehanochelys trijuga* (Turtle), *Monopterus cuchia*, *Ophiophagus hannah* (King cobra), *Eonycteris spelaea* (Bat); *Ursus thibetanus*, *Capricornis sumatraensis*, *Macaca assamensis*, *Manis* sp., *Petaurista petaurista* (Red giant flying squirrel), *Hystrix* sp., *Uttaney musa* (Mole), *Bos taurus* (cattle), and *Periplaneta americana*.	Adi of Arunachal Pradesh; Rural communities of Dibrugarh, and Biate of Assam; Mizo, Bru and Chakma of Mizoram; Ethnic groups of Manipur; Lepcha, Bhutia and Nepali of Sikkim.	Kalita et al. (2005); Chinlampianga et al. (2013); Betlu (2013); Devi et al. (2015); Solanki et al. (2016); Dhakal et al. (2019).

Table 4. Conservation status (IUCN 2020) of animals used for ethno-zoological applications in NE India

Name of the animal species	IUCN 2020 status
Amblypharyngodon mola (Indian Carpet Fish)	LC
Amphipnous cuchia (Cuchia)	LC
Antilocapra americana (Antelope)	LC
Bufo melanostictus (Toad)	LC
Canis aureus (Golden Jackal)	LC
Centropus sinensis (Greater Coucal)	LC
Chaca chaca (Fish)	LC
Channa punctatus (Snakehead fish)	LC
Civettictis sp. (Civet)	LC
Clarias batrachus (Magur fish)	LC
Columba livia (Pigeon)	LC
Crotalus durissus (Neotropical Rattle Snake)	LC
Cynopterus sphinx (Bat)	LC
Echis coloratus (Viper)	LC
Eutropiichthys vacha (Fish)	LC
Eutropis carinata (Common Indian skink)	LC
Felis silvestris (Wild Cat)	LC
Gallus domesticus (Chicken)	LC
Gekko gecko (Tokay Gecko)	LC
Herpestes sp. (Mongoose)	LC
Heteropneustes fossilis (Singing catfish)	LC
Hystrix indica (Indian Porcupine)	LC
Labeo rohita (Fish)	LC
Lepus capensis (Rabbit)	LC
Lepus nigricollis (Hare)	LC
Lymnaea sp. (Water snail)	LC
Macaca mulatta (Rhesus Macaque)	LC
Mantis religiosa (Praying Mantis)	LC
Martes flavigula (Yellow Throated Marten)	LC
Mastacembelus armatus (Spiny Eel Fish)	LC
Maydelliathelphusa lugubris (Fresh Water Crab)	LC
Megalaima sp. (Barbet)	LC
Mus musculus (House mouse)	LC
Mustela sp. (Weasel)	LC
Mystus bleekeri (Fish)	LC
Naja naja (Cobra)	LC
Nanorana liebigii (Frog)	LC
Petaurista petaurista (Red Giant Flying Squirrel)	LC
Pheretima sp. (Earthworm)	LC
Picus canus (Black Napped Green Woodpecker)	LC
Polypedates leucomystax (Common Tree Frog)	LC
Prionailurus bengalensis (Leopard Cat)	LC
Pseudois nayaur (Himalayan Blue Sheep)	LC
Pteromys sp. (Flying Squirrel)	LC
Puntius sp. (Fish)	LC
Rana sp. (Frog)	LC
Rattus sp. (Rat)	LC
Rhizomys sumatrensis (Bamboo Rat)	LC
Sartoriana sp. (Red Freshwater Crab)	LC
Scylla sp. (Mud crabs)	LC
Struthio camelus (Common Ostrich)	LC
Sus scrofa domestica (Pig)	LC
Talpa sp. (Hill mole)	LC
Varanus bengalensis (Monitor Lizard)	LC
Viverra zibetha (Large Indian Civet)	LC
Viverricula indica (Small Indian Civet)	LC
Vulpes bengalensis (Fox)	LC
Xenentodon cancila (Freshwater Gar Fish)	LC
Arctonyx collaris (Hog badger)	VU
Buceros bicornis (Great Hornbill)	VU
Buceros sp. (Hornbill)	VU
Budorcas taxicolor (Takin)	VU
Cyprinus carpio (Common Carp)	VU
Dicrurus sp. (Drongo)	VU
Haliaeetus sp. (Eagle)	VU
Helarctos malayanus (Malayan sun bear)	VU
Hoolock leuconedys (Eastern Hoolock Gibbon)	VU
Lutrogale perspicillata (Smooth Coated Otter)	VU
Melursus ursinus (*Sloth* bear)	VU
Neofelis nebulosa (Clouded Leopard)	VU
Ophiophagus hannah (King Cobra)	VU
Panthera pardus (Leopard)	VU
Pteropus sp. (Flying Fox)	VU
Python molurus (Indian Python)	VU
Rhinoceros unicornis (Rhino)	VU
Semiplotus sp. (Fish)	VU
Trachypithecus pileatus (Capped Langur)	VU
Ursus thibetanus (Himalayan Black Bear)	VU
Wallago attu (Fish)	VU
Amblyceps sp. (Catfish)	EN
Anguilla sp. (Eel)	EN
Axis porcinus (Hog Deer)	EN
Bubalus arnee (Wild Water Buffalo)	EN
Manis crassicaudata (Indian Pangolin)	EN
Moschus sp. (Musk Deer)	EN
Nycticebus sp. (Slow loris)	EN
Panthera tigris (Tiger)	EN
Platanista gangetica (River Dolphin)	EN
Bagarius sp. (Gangetic Goonch)	NT
Hemitragus jemlahicus (Himalayan Tahr)	NT
Labeo pangusia (Fish)	NT
Macaca assamensis (Assamese Macaque)	NT
Naemorhedus goral (Himalayan Goral)	NT
Pardofelis sp. (Marbled cat)	NT
Testudo sp. (Tortoise)	NT
Chiroptera sp. (Bat)	CR
Geochelone emys (Eastern Hill Tortoise)	CR
Manis sp. (Pangolin)	CR
Callosciurus (Oriental Tree Squirrel)	DD

Note: LC: Least Concern; VU: Vulnerable; EN: Endangered; NT: Near Threatened; CR: Critically Endangered; DD: Data Deficient

Discussion

This study is an attempt to highlight the available knowledge on ethno-zoological therapeutic applications used by different traditional healers and indigenous communities of northeast India. Ethno-medicinal practices have been well known and in use for a long time, but reportedly limited pertaining to studies based on animals in NE India. Such studies on animal-based medicines and their mode of application in NE India are relatively limited and fragmentary due to various reasons that also include the oral transmission of knowledge that gradually declines among local communities. Analysis of literature helped us to discover the traditional cure of ailments with ethno-zoological treatments practiced by various tribes of NE India (Solanki and Chutia 2004; Jamir and Lal 2005; Kakati et al. 2006; Verma et al. 2014).

The present investigation shows that various indigenous communities use animals in their traditional medicines in all of the eight NE Indian states (Table 2-3). In Arunachal Pradesh, the use of animal-based medicines by traditional healers was never reported systematically earlier, except for a few reports from Pandey et al. (1999), Solanki (2002), Solanki et al. (2004), Solanki and Chutia (2004), Solanki (2006) and Chutia (2006) in the 21st century. A review of literature in Arunachal Pradesh reveals that large-scale use of animal-based ethnomedicine still remained largely undocumented in the state. In Assam, reviews of the available information on ethno-zoological therapeutic procedures and the use of particular organs/body parts of animals for specific diseases are still unexplored and fragmentary; which is believed to be large because local healers share their formulations of therapeutic products with a highly conservative approach. Whole body, meat, soft watery section, etc. are some of the ways the local and traditional healers use animal parts/organ in applying traditional disease healing in Assam. In Manipur, animal parts such as skin, hair, bones, animals and by-products such as urine are usually used in zoo-therapeutic treatments; and secretions of the gland are used in magico-religious and faith-healing rituals; while endoskeletons and exoskeletal parts of animals are used as "charms" to expel evil spirits (Devi et al. 2015).

In Meghalaya, Mizoram, Nagaland, Sikkim and Tripura the application of use of mammals and mammalian products have been observed to be highest, including Arunachal Pradesh and Assam. In Sikkim, Dhakal et al. (2019) stated that parts of the body used in their ethno-zoological medicinal applications included bones, meat, teeth, gall bladder, skin, musks and horns used for dysentery, fractures, tuberculosis, common cough and cold and fever, diabetes, malaria, and piles. In Tripura, Das (2015) had reported that several parts of the body, such as urine, blood, flesh, entire body, feces, etc. are usually used for diagnosis of human ailments depending on the type of ailment and its possible mode of action.

Application of fish-based medicines in the state of Manipur is prevalent compared to other animal species (Figure 4). In Arunachal Pradesh, use of insects is the highest in traditional medicine in comparison to other states (Figure 2). Several other animal groups such as birds, rodents, amphibians, annelids, mollusks, crustaceans, and arachnids are also used for traditional medicines in these communities depending on the type of ailments.

Application of mammals

All NE Indian states, excluding Manipur, recorded the highest use of mammals as compared to other species of animals. Similar findings have also been reported in other parts of India, where use of mammals in traditional medicine is comparatively higher than use of other animal groups (Mahawar and Jaroli 2008). Jaroli et al. (2010) and Chellappandian et al. (2014) were of the opinion that mammals are readily accessible for optimal use in traditional medicine. However, Dhakal et al. (2019) were of the opinion that increased use of mammals may be attributed to the growing number of domesticated mammals and the ethnic communities' association with mammals.

Application of fishes

The review shows that for indigenous communities of NE India, fish have also been the essential resource for traditional medicines, apart from being a good nutrient intake and an integral part of folk ritual. This is evident from the studies conducted in Manipur, resulting in their overuse and thereby leading to over-exploitation (Devi et al. 2015; Chanu et al. 2016). Chanu et al. (2016) stated that the use of *Channa orientalis* in different types of traditional medicines and religious purposes is one of the reasons for drastic reduction of this fish species in the natural habitats. Another example is the use of *Channa orientalis* and *Channa punctatus* as 'goodwill charms' amongst some tribes in Manipur during marriage ceremonies, New Year's Day of Meitei tribes, taken in fermented forms by ailing patients. The skin, eyes, whole body, flesh and scales are widely used body parts of fish for therapeutics. (Devi et al. 2015).

Application of insects

In addition to mammals and fish, insects were also observed as one of the most important sources of ethnomedicine in NE India. Traditional knowledge and acceptance of insects as food and for local therapies have been found to be highly prevalent in Arunachal Pradesh (Dagyom and Gopi 2009; Chakravorty et al. 2011a), Meghalaya (Mihsill and Keshan 2011) and with lesser use in other states of NE India. It is observed that insects are used during the larva stages, pupal stages and also in adult stages in traditional medicine (Chakravorty et al. 2011a). Rodriguez and Levin (1976) believed that since insects and plants use similar chemical compounds for defense mechanisms, the use of pharmacological activities from such insect species that feed on plants producing drugs becomes a potential source of ethno-zoological medicines.

Application of animal body parts

Flesh, meat, bones, bone marrow, fats, gall bladder, food pipe, reproductive organs, horns, feather and legs of birds, animal fetuses, fat, hair, skin, liver, teeth, musks, ears, tongue, neck, hands, arms, skin and male organs are widely used in NE India (Table 2). It is also observed that in ethnomedicine animal products like urine, blood, bile juice, milk, and soft watery portions were used.

The review shows that there is still lack of research on traditional medicines based on animals by the indigenous communities of NE India, especially in the state of Meghalaya, Mizoram, Nagaland, Sikkim and Tripura (Table 2-3). Further, documentation needs to be carried out with respect to traditional medicines based on animals by Garo, Jaintia and Bhoi communities of Meghalaya. Use of elephant teeth in food poisoning by the Khasi community of Meghalaya needs to be documented.

CONCLUDING REMARKS

Traditional medicine using animals has been playing vital roles in the ethnic health care system for ages. However, equally vital is the fact that taking utmost care of ecological balance while practicing traditional medicines using animals and animal products requires attention to conserve our rich biodiversity. Gradual changes in eco-system patterns as a result of deforestation, jhum farming, uncontrolled fishing, etc., lack of awareness of conservation and preservation, and other factors, have posed serious threat to the existing ethnomedicinal plants and animals in NE India (Yirga et al. 2011). The traditional ethnomedicinal practices require prompt recognition by authorities and further strengthening with the help of incentivized training and education programs (Dhakal et al. 2019). Creation of database on the practitioners and the mode of treatment would prioritize creation of policies and regulations thereby enforcing a safeguard on natural resource exploitation. Responsible roles by the traditional healers while practicing local medicine would lead to an effective balance between nature and traditional medicine. An integrated approach towards potential uses of traditional medicine using animals would not only conserve our rich natural resources, but also aid in preserving cultural heritage as well. For aquatic species, a conservation and sustainable strategy need to be implemented while utilizing these species for traditional health practices. Additionally, scientific awareness, management and conservation measures of animal resources would enhance better connectivity with nature.

NE India accounts for only 8% of the geographical area of India; however, around 60% of the country's endangered species flourish in the region (Choudhury 2006). There are many species that are native to this area, such as the Indian Rhinoceros, Wild Buffalo, primate species, etc., used for ethno-zoological applications. Several primates are reportedly believed to have been hunted in Arunachal Pradesh, Assam, Mizoram, and Tripura, and for several superstitious beliefs and possession of medicinal properties (Gupta et al. 2014). Aiyadurai (2011) recorded that out of a total of 50 native Indian species of Galliformes (land fowls), 32 occur exclusively in NE India. The share of NE India is relatively high in the case of 'Vulnerable' birds and reptiles: 74% and 80% respectively (Choudhury 2006). Gupta et al. (2014) recorded that 11 of the 16 primate species in India are recorded to live in NE India; and with the exception of three species, due to many anthropogenic activities, remaining primate species have faced serious threats. As recorded by Gupta et al. (2014), other species known to be endangered in North-eastern states due to several anthropogenic pressures include slow loris, tiger, leopard, bear, serow, goral, yak, sheep, pangolin, river dolphin and several bird and reptile species. Present study also reflects that several vulnerable, endangered, near threatened and critically endangered species are being used for ethno-zoological applications in NE India (Table 4).

Wildlife hunting poses a high risk to the survival of wildlife species in this area due to the fact that indigenous communities of the North-East are largely dependent on ethnozoological applications for traditional medicine (Aiyadurai 2011; Gupta et al. 2014). A major reason why wildlife hunting is seen as a difficult problem to address is the relation between hunting and the socio-economic needs of local people; and the same balance needs to reduce the adverse effect of hunting on wildlife populations and the reliance of rural communities on wildlife for food, medicine, etc. (Aiyadurai 2011). Long-term conservation measures such as education, eco-tourism, and the establishment of more protected areas may be necessary to provide a sustainable existence of ethnomedicinal applications as well as the conservation of endangered species in order to cover as much habitat as possible and to check for habitat destruction, fragmentation, deforestation, wildlife hunting and pollution, which are critical to the existence of diverse species in the region. In addition, a database of available species will provide a deeper understanding of the conservation strategy and of the region's species composition.

The traditional healers need to be sensitized and made aware of the extant Acts and Rules pertaining to wildlife conservation (Tynsong et al. 2020). However, ethno-zoological application of animals is a matter of serious concern connected with illegal trade in wildlife where animal parts/animal products such as gall-bladder of Himalayan Black Bear, goral horns, pangolin scales, monkey flesh, etc. are rarely available (Dhakal et al. 2019). Reports indicate that subsequently, scarcity has led to a decline in ethno-zoological traditional medicines among indigenous communities in Sikkim (Dhakal et al. 2019). Studies conducted by Dhakal et al. (2019) also suggest amphibian species such as *Nanorana liebegii* and *Amolops himalayanus* have a high value of ethnomedicinal properties in zoo therapy and are therefore prone to overexploitation.

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Pharmacognostic studies and anatomical peculiarities in medicinal plant *Enicostemma axillare*

KANCHAN SANDEEP DHAWLE, UMESH PRAVIN DHULDHAJ, RAMJAN MAHAMUDDIN MULANI♥
School of Life Sciences, Swami Ramanand Teerth Marathwada University, Nanded 431606, Maharashtra, India
♥email: rmmulani1961@gmail.com

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Abstract. *Mulani RM, Dhawle KS, Dhuldhaj UP. 2021. Pharmacognostic studies and anatomical peculiarities in medicinal plant, as* Enicostemma axillare. *Asian J Ethnobiol 4: 23-30.* Pharmacognostic evaluations were carried out by plant material collection, preparation of herbarium, organoleptic properties, macroscopic characters, and microscopic characteristics. For the physiological studies, Transverse Sections (T.S.) of root, stem, and leaves were taken, powder analysis, physicochemical value determination such as total ash, water-soluble ash, acid-soluble, and acid-insoluble ash were done. The distinctive characters of *Enicostemma axillare* (Poir. ex Lam.) A. Raynal stem is the presence of parenchyma. Leaves microscopy indicates the presence of anisocytic stomata, minor leaf veins, phloem transfer cells, and numerous sclereids. Macroscopic study shows leaves and roots with glabrous-surface, and stem was tall simple to branch and maybe prostrate or ascending. Color variation indicates the presence of different components and essential oils; determined the percentage of leaf, stem, and root: ash values; water-soluble, acid-soluble, and acid-insoluble ash values. This study provides anatomical properties for the proper identification and establishment of standards of *E. axillare* for the medicinal applications to treat diabetes mellitus, rheumatism, abdominal ulcers, hernia, swelling, itching, and insect poisoning. This helps in the pharmacognostical standardization of drugs in crude form and differentiates them from adulterations.

Keywords: Adulteration, *Enicostemma axillare,* medicinal plant, organoleptic properties, pharmacognosy

INTRODUCTION

Medicinal plants are used in Unani-Tabbi, Ayurved, Siddha, Homeopathy, Allopathy and Naturopathy, and Home Remedies. This rate is higher in African countries, where up to 90% of the total population relies on medicinal plants to help their primary health care needs (Adewale and Oduyemi 2014). Herbal medicines are one of the promising choices other than modern synthetic medicines. In Sudan, traditional medicines prepared from medicinal plants showed antiplasmodial activity (Ahmed et al. 2010). The increasing popularity of herbal remedies worldwide suggests rules for their regulations (Ameh et al., 2011). Medicinal plants play a very active role in traditional medicines to treat various ailments. According to the World Health Organization (WHO 2011), it is estimated that 80% of the whole world's population, especially for millions of vast rural areas of developing countries, people use medicinal plants for the treatment of various types of diseases as a primary health care needs (Bhargava et al. 2013; Raja et al. 2015).

The green plants provide food, clothing, shelter, and all other needs for human beings (Mathew and Babu 2011). Plant identification is necessary as far as the actual sample of crude drugs is required for the efficacy of the natural medicines. It includes pharmacognostic studies, mainly anatomical and morphological parameters which help in the authentification of crude drugs (Shahina and Nampy 2014). In herbal technology, pharmacognostic plays an essential role in providing standardization parameters that will help prevent adulterations in the original plant material and ensure correct plant identity. This information will help authenticate the plants and ensure the reproducible quality of herbal products resulting in the safe use and retaining the effectiveness of natural products (Shahina and Nampy 2014; Chaudhari and Mahajan 2015). Medicinal plants have been recognized from time immemorial and are also known throughout the world as a rich source of therapeutic agents in preventing various diseases (Mathew and Babu 2011). Herbal medicine is a very important branch in Ayurvedic Medical Sciences, but there is a lack of standard identification methods. *Enicostemma axillare* is flower producing herbaceous, perennial plant growing up to 1.5 feet (Shahina and Nampy 2014).

The word '*Enicostemma*' is derived from three words 'en' means inside, 'icos' means twenty, 'stemma' means wreath, referring to the arrangement of about twenty flowers around every node of the stem (Shakya 2016; Upreti et al. 2013; Sanmugarajah et al. 2013). *Enicostemma axillare* occurs in grasslands, sea coasts, and peninsular India. It is cosmopolitan and exhibits variations in the habit (Zaheer et al., 2011). It is found throughout India, and marine conditions and highly alkaline are favorable for the *Enicostemma axillare* (Poir. ex Lam.) A. Raynal. When growing in good soil, away from the seashore, this plant attains a larger size with large, broad leaves than the one near the sea. The plant is also native to tropical Africa, Southeast Asia, Malaysia, Africa to the Lesser Sunda Islands. The crude drug or plant is commonly called Nai or Kadvi-nayi. The focus of this study was Pharmacognostic studies and anatomical peculiarities in *Enicostemma* *axillare*, while there is not much work on pharmacognostic details of this plant.

MATERIALS AND METHODS

Plant materials

Enicostemma axillare is a small plant species growing at various sites in SRTM University campus, Nanded, Maharashtra, India. The plant species occur naturally throughout the year wherever moisture is there, generally in open places amongst the grasses. It is a tropical plant that grows well at 22-25 ^{0}C. Fresh, healthy plant materials for the study were collected from various places during the summer season (May 2019) from the same campus of latitude 19º06'27.3" N and longitude 77º17'22.1" E with altitude 1500 ft and brought to the laboratory. The climate conditions of the SRTMU Campus in the wet seasons are hot and humid and in dry seasons are uncomfortably hot and mostly clear with an annual average temperature of 13 ºC to 42 ºC. The herbarium specimen was made and submitted in Botanical Depository of SRTMU Nanded. The proposed plant species was identified and authenticated by the expert Prof. (Dr.) Ramjan M. Mulani, Department of Botany, School of Life Sciences, SRTM University, Nanded with detailed taxonomic study and given the herbarium voucher number SRTMU/SLS/Bot/Herb/116/RMM/2019-20.

Morphological and anatomical observation

The remaining plant material was processed for anatomical characterizations. In macroscopic evaluation, various parts were checked externally for the length, breadth of the leaves and stem, and roots. The microscopic evaluation was done on a qualitative basis. The leaf, stem, and root anatomy was studied using fresh samples. Stems were sampled at the 2nd and 3rd internodes. The qualitative microscopic study used freehand transverse sections of washed leaves, stems, and roots and from epidermal peelings.

Physicochemical observation

Color variations were observed in the crude powder of different *Enicostemma axillare* parts', such as leaves, stems, and roots. Fluorescence analysis of the whole plant powder was carried out using the standard method (Akbar et al., 2014; Pathan et al., 2018). The analysis treated the plant powder with different solvents, including acidic and basic. After treatment, they were exposed to UV light (short wavelength of 254 nm and long wavelength of 365 nm) and observed in daylight (Akbar et al. 2014). Color variation is to be analyzed and kept in the crude powdered extracts, i.e., leaves, stems, and roots materials of the *Enicostemma axillare* under ordinary light, short ultraviolet wavelength (254 nm), and long ultraviolet wavelength (365 nm), after treatment with the following 14 different types of organic and inorganic reagents.

Organic reagent: Picric acid, acetic acid, lactic acid, ferric chloride, Sudan III, methanol.

Inorganic reagent: Conc. H_2SO_4, conc. HNO_3, HCl, iodine, NaCl, NaOH, ammonia, water.

Physical constant determination: The total ash: To measure total ash, an empty silica crucible ignited to red hot and allowed it to cool down. It's Weighed and tear zero. Accurately weighed 2 gm of grounded crude drug of *Enicostemma axillare* leaves, stem, and roots were taken into previously weighted silica crucible and weighed. Further, the drug is taken in a crucible heated with increasing heat up to 450 ºC, till the powder becomes red hot. The obtained ash appearance of white coloration was transferred to desiccators and weighed again with silica crucible, and further, the percentage of Ash value was calculated (Momin and Kadam 2011).

$$\text{Percent of total ash} = \frac{\text{Initial weight-Final weight}}{\text{Initial weight}} \times 100$$

Water-soluble ash: The above obtained total ash boiled with 25 ml of distilled water for 5 min and insoluble ash material separated with the help of ashless filter paper and washed with hot water and heated, further let it cool down, and weighed again. Subtract the weight of insoluble matter from the weight of the ash; the difference in weight represents the water-soluble ash. The ash value of the drug and the percentage of water-soluble ash concerning the air-dried drug was calculated as mentioned below:

As Total Ash = Water-soluble ash + Water-insoluble ash
Therefore, Water-Soluble Ash = Total ash – Water-insoluble ash

$$\text{Percentage of water-soluble ash value} = \frac{\text{Initial wt. - Final wt.}}{\text{Initial weight}} \times 100$$

Acid insoluble ash: The above obtained total ash boiled with 25 ml of dil. HCl for 5 min and insoluble ash material separated and washed with hot water and heated, let it cool down and weighed again. Concerning air-dried ash value of the drug calculated as mentioned below:

Total ash = Acid-soluble ash + Acid insoluble ash

Acid-soluble ash = Total ash – Acid insoluble ash

$$\text{Percentage of acid-soluble ash value} = \frac{\text{Initial wt. - Final wt.}}{\text{Initial weight}} \times 100$$

RESULTS AND DISCUSSIONS

Enicostemma axillare collected from the campus of the Swami Ramanand Teerth Marathwada University. Identification of the plant is made by depositing herbarium sheet of the plant to the depository of Department of Botany, School of Life Sciences, SRTMU, Nanded, India, and herbarium sheet number of the plant is SRTMUN/SLS/BOT/HERB/116/RMM /2019-20 obtained. This plant can treat fever, rheumatism, skin diseases, abdominal disorders, snake bite, obesity, malaria, and diabetes. Species of *Enicostemma* have particular importance in Indian medicine as they also have antimicrobial, antiulcer, hepatoprotective, anti-inflammatory, hypoglycemic, and hypolipidemic activities (Saranya et al., 2013; Zaheer et al. 2011).

Organoleptic evaluation/macroscopic evaluation

In macroscopic evaluation, we found a difference between fresh plant parts and dry plant parts like leaves, stems, and roots based on color, shape, and size (Table 1). Fresh leaves of *Enicostemma axillare* are simple, opposite, sessile-sub sessile; sometimes narrowed into a petiole like base, longer than the internodes, pale-dark green in color, spiral, absence of petioles, rough in texture, strongly aromatic with characteristic odor and bitter taste (Figures 1-2). Lamina base is sessile, linear to lanceolate or narrowly oblong (5.0-8.0 x 0.3-1.0) cm^2 long, lamina indentations, entire, obtuse, acute-mucronate at the apex, somewhat narrowing towards the base, 3-nerved from the ground, texture leathery, possesses minor leaf veins and phloem transfer cells (Figure 3). Dried leaves are dark green, characteristically odored with a bitter taste, crooked, diameter (4.0-7.0 x 0.2-1.0) cm^2. Dried leaves powder is a touch course (Figure 2).

Fresh greenish-yellow stems are terete or quadrangular, i.e., 4-angled; cylindrical, 15-45 cm or 1.5 ft tall that may be prostrate to ascending, long, green, pungent in odor, highly bitter taste, simple or branched, internodes 0.5-1.2 cm long, herbaceous greenish-yellow in nature (soft), glabrous with a decurrent ridge below each leaf. Dried stems are yellowish-green with a strong, pungent odor, the taste is very bitter, and no change in shape and size (Figures 1-2). Dried yellowish green stem powder is a touch course.

Roots are whitish-yellow in color, odor - Pungent, highly bitter taste, cylindrical or branched-profusely branched, length 15-20 cm, and diameter 2.5 cm without hairs. Dried roots are light brown with Pungent, bitter taste, crooked, length 15-20 cm, and 2 cm in diameter. Root hairs were absent (Figure 2). Dried light brown powder of roots is a touch course (Figure 3).

Anatomical peculiarities:

The epidermis is single-layered, irregularly shaped cells; the outer cortex is broadly parenchymatous with many-layered fibers arranged between the cortical parenchyma and the secondary phloem. The secondary phloem follows the secondary xylem. The secondary xylem has a significant arrangement of xylem that is metaxylems are towards the outer side, and protoxylems are towards the inner side. The primary phloem follows the secondary xylem. Inside the primary phloem, there is a xylem region and absence of root hairs (Figure 4).

Both fresh and dried stems show terete or quadrangular outline, angles have multicellular wing-like structures, and the epidermis is single-layered. Compactly arranged, unicellular cells are round with parenchymatous chlorophyll without intercellular spaces, thick cuticles. The hypodermis is 2-layered, collenchymatous. Cortex is a thick two-layered parenchymatous with chlorophyll, subepidermal sclereids, and Sphaeraphides in the pith region.

Vascular cambium having both external and internal called secondary included phloem (Including phloem tissue lying within the secondary xylem in the continuous band above the xylem band). Protoxylem present towards the inner region and metaxylem towards the outer part forming conjoint vascular bundle with the presence of outer cambium just beneath the secondary phloem and inner cambium below the secondary xylem. There is an initial secondary growth with the addition of secondary xylem towards the inner side. The vascular cylinder consists of secondary xylem, secondary phloem, and Vascular cambium with pith into the center (P) (Figure 5).

The whole leaf shows minor leaf veins with phloem transfer cells; midrib region is haplostele; chlorenchymatous single-layered epidermis and hypodermis are made up of Mesophyll tissues is compact chlorenchymatus with mucilage cells. Lamina is differentiated into two layers: palisade tissue towards the adaxial epidermis, i.e., the upper surface of the leaf, and spongy chlorenchyma is just at the abaxial side means the lower surface of the leaf. The vascular bundle is present in the cortex region of the midrib. It is of conjoint type, i.e., xylem and phloem are arranged in the same radius (collateral) and open, i.e., cambium. Bundle sheath extension is of chlorenchymatous. Xylem elements are facing upwards. The lateral leaf has lamina indentations on both sides. The leaf surface showing stomata on the abaxial epidermis (lower surface) is of anisocytic and anomocytic types; two guard cells are surrounded by 3 subsidiary cells, of which 2 are more significant, and one is distinctly smaller (Figure 5).

Figure 1. The habit of *Enicostemma axillare* in the campus of Swami Ramanand Teerth Marathawada University, Nanded, India

Table 1. Macroscopic characteristics of plant material

Characters	Fresh			Dry		
	Leaves	Stems	Roots	Leaves	Stems	Roots
Color	Whitish green	Green	Yellowish white	Dark green	No change	Dark brown
Odor	CR	CR	CR	CR	CR	CR
Taste	Bitter	Bitter	Bitter	Bitter	Bitter	Bitter
Shape	Lamina narrowly linear-oblong	Terete or 4-angled	Cylindrical, branched-profusely branched	Crooked	No change	Crooked
Size	(5.0-8.0 x 0.3-1.0) cm	15-45 cm or 1.5 feet	L=15-20 cm D=2.5 cm	(4.0-7.0 x 0.2-1.0) cm	No change	L=15-20 cm, D=2 cm
Touch	Smooth	Soft	Hard	Course	Course	Course

Abbreviation: L: Length, D: Diameter, CR: Characteristics

Figure 2. Organoleptic characters of *Enicostemma axillare*; A. Fresh whole plant, whitish-green leaves and stems, whitish-yellow roots, B-C. Dried dark green leaves and powder, D. Dried yellowish-green stems, E. Dried yellowish green stem powder, F-H. Fresh roots, dried crooked roots, and light brown powder

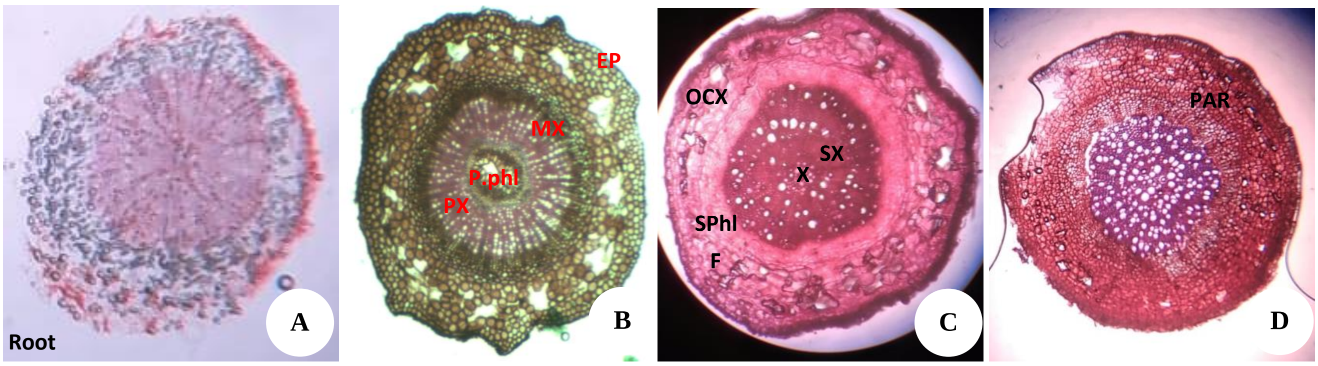

Figure 3. Root T.S. of *Enicostemma axillare*; (A-B): Fresh Roots: Epidermis (EP), 1-layered, cells irregular, (Outer cortex-OCX) broadly Parenchymatous (PAR). Fibers many-layered (F), arranged between the cortical parenchyma and the secondary phloem (SX); Proto xylem (PX), Metaxylem (MX); inside Primary phloem (P.Phl) presence of Xylem (X). Pith and Root hairs absent. (C-D): Dried Roots: epidermis 1-layered, cells irregularly shaped. The outer cortex is broadly parenchymatous. Fibers are many-layered, arranged between the cortical parenchyma and the secondary phloem (SPhl). Root hairs absent.

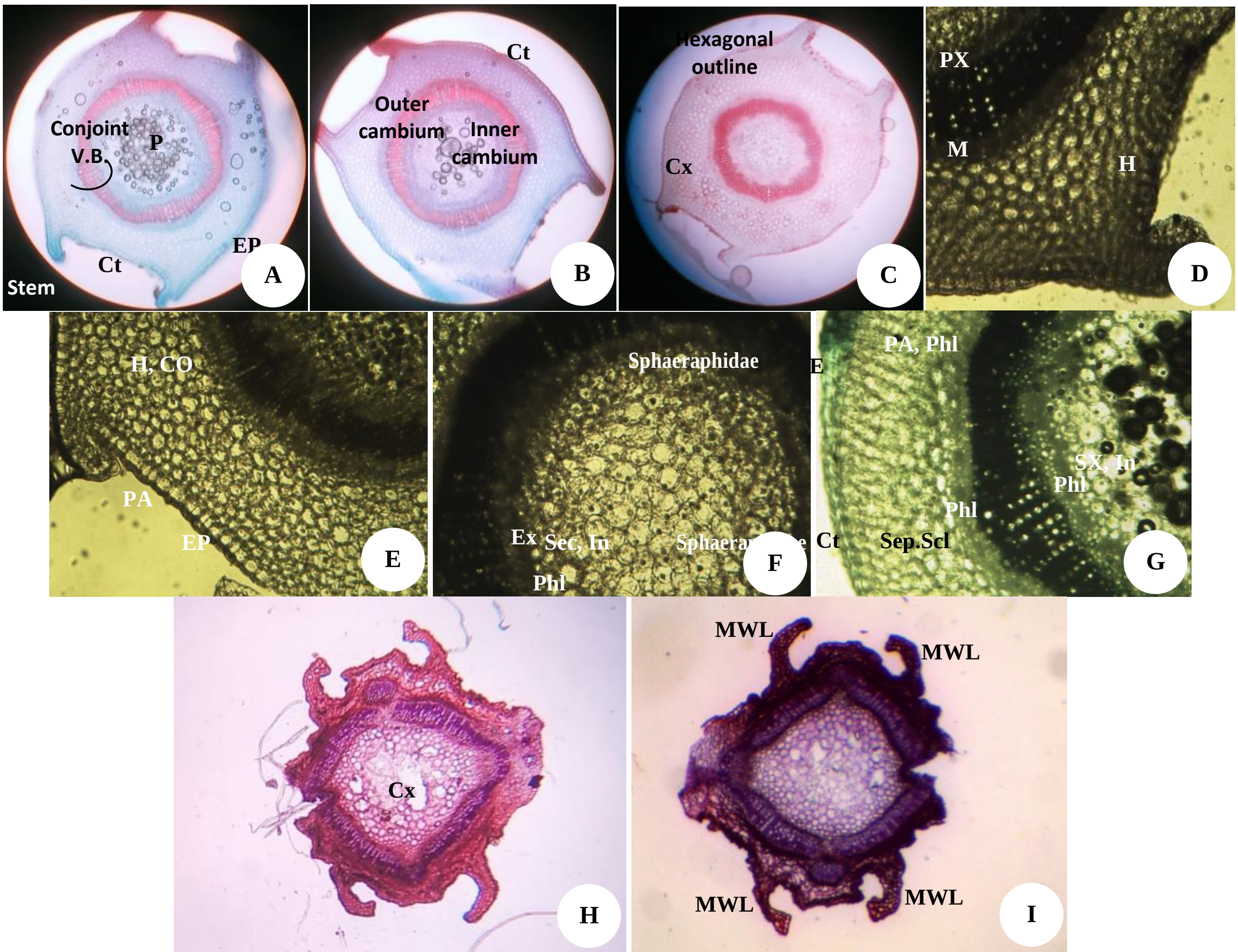

Figure 4. Stems transversal section of *Enicostemma axillare*; A-B. Fresh Stems: epidermis 1-layered (EP), cells round, parenchymatous (PAR) without intercellular spaces, covered with cuticle (Ct), Conjoint vascular bundle with the presence of outer cambium just beneath the secondary phloem and inner cambium below to the secondary xylem, pith is into the center; C. Showing hexagonal outline, 2-layered. Cortex (Cx), parenchymatous (PAR), chlorophyll (Chl); D. Hypodermis (H) 2 layered collenchymatous (CO), Protoxylem (PX), and Metaxylem (MX). E. Fresh Stems: 1-layered Epidermis (EP), cells round, Parenchymatous (PAR) without intercellular spaces, covered with thick cuticle (Ct), F. vascular cambium, phloem is present in the continuous band on both sides of xylem band, sphaeraphides are occasionally seen. G-I. Dried Stems: 1-layered Epidermis (EP), compactly arranged unicellular small round cells are Parenchymatous (PAR) without intercellular spaces, covered with thick Cuticle (Ct); Hypodermis (H); Collenchymatous (CO), 2-layered. Thick Cortex (Cx), parenchymatous chlorenchyma (PAR, Chl), Subepidermal *Sclereides* (Sep, Scl), Phloem (Phl) both External (Ex) and Internal (In), secondary included (Sec, in) [included phloem (phl): phloem tissue lying within the Secondary xylem SX]. There is an initial sec. Growth with the addition of Secondary xylem (SX) towards the inner side (SX, in). The vascular cylinder consists of Secondary Xylem (SX), Secondary Phloem (SP), and Vascular Cambium (VC) pith phloem (P), Angles have Multicellular wing-like structures (MWLS).

Fluorescence characteristics and powdered analysis

For the powder analysis, we took 14 reagents and tested against crude powder of Enicostemma axillare of different plant parts like roots, stems, and leaves and visualized against other light sources such as visible, UV 254 nm, and UV 365 nm. In these investigations, each light source has shown different color variations in reagents tested on plant samples. Crude powder extract and distilled water have not demonstrated any color variation in light sources. For leaves, stems, and roots, it has shown henna green, yellowish-green, and straw yellow colors respectively in all the three types of light sources, i.e., visible, UV 254 nm, and UV 365 nm. Similar color variations are observed with reagents such as picric acid and Conc. H_2SO_4, Conc. HNO_3, HCl, acetic acid, lactic acid, Iodine, Sudan III, Ammonia, NaOH in methanol and NaOH (details are given in Table 2).

Constant value: Total ash value of the crude extract of the *Enicostemma axillare* were calculated, and it was found that among total ash content; (12.5%) of leaves, (11.45%) of stems and (11.10%) of roots; water-soluble were (5.30%) of leaves, (4.25%) of stems and (6.52%) of roots; insoluble acid ash were (7.40%) of leaves, (7.20%) of stems and (7.10%) of roots and acid-soluble ash were calculated as (6.10%) of leaves, (5.25%) of stems and (5.00%) of roots (see Table 3).

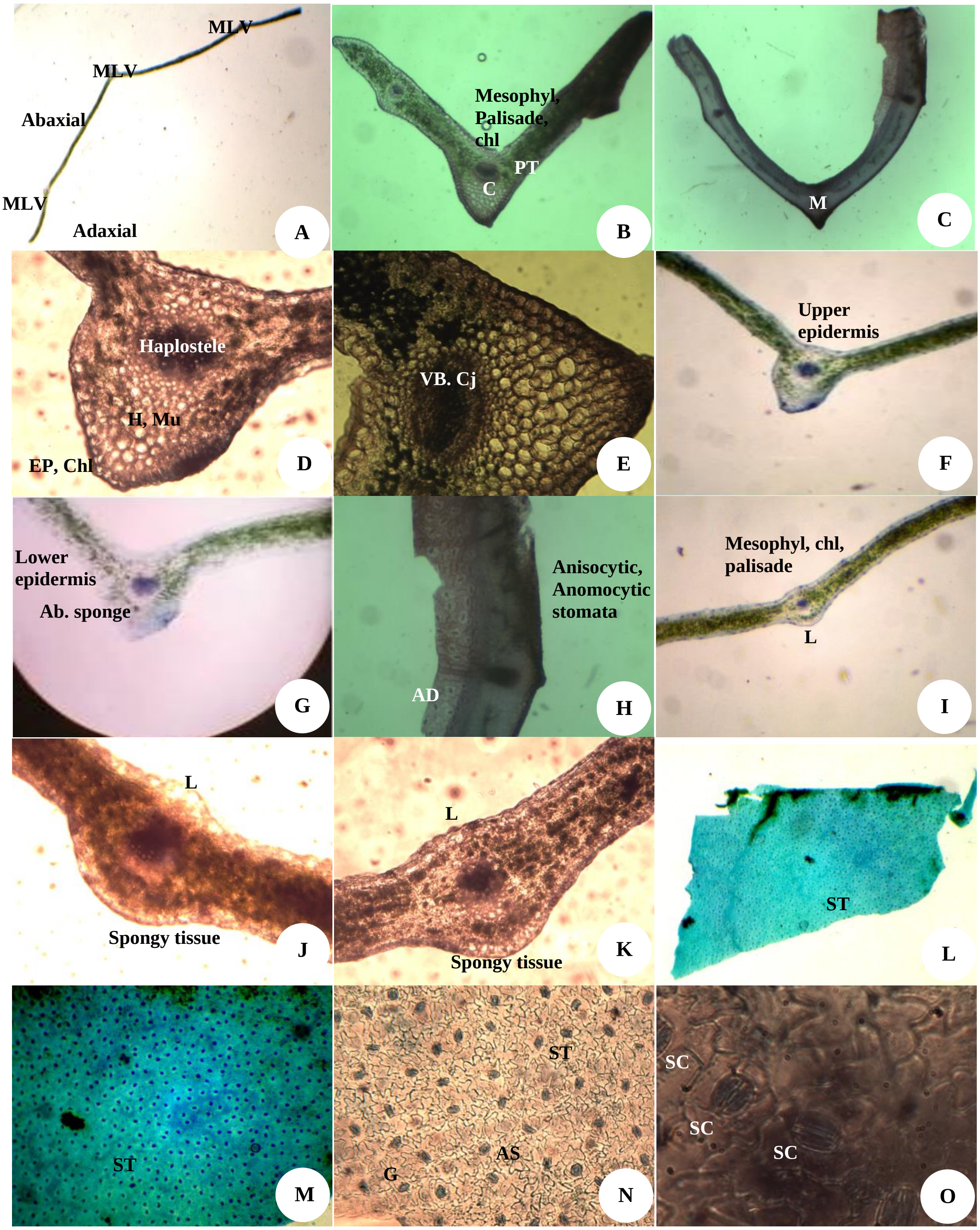

Figure 5. Anatomical details of leaves of *Enicostemma axillare*; A–C. T.S.; minor leaf veins (MLV) with Phloem transverse cells (PTC); Midrib region (M), D–H. Midrib (M): 1- layered epidermis chlorenchymatous epidermis (EP, Chl). Hypodermis (H): Mesophyll without Mucilage (Mu). Lamina is differentiated into 2-layered, i.e., palisade towards the adaxial epidermis (upper) and spongy chlorenchyma just at the abaxial epidermis (lower) mesophyll is compact chlorenchyma. Vascular bundle (VB): present in the cortex of midrib region, conjoint (Cj), i.e. [Xylem(X) and Phloem (P)] arranged together in same radius (collateral) and opened with cambium. Bundle sheath extension chlorenchymatous, Stele is haplostele, Xylem elements are facing upwards, Minor leaf veins (MLV) with Phloem transverse cells (PTC) are present, stomata are of anisocytosis and anomocytic). I–K. (L) lateral leaf showing lamina indentations, mesophyllous chlorophyll, palisade tissue on the upper surface, and spongy tissue at the basal epidermis. L–O. leaf surface showing stomata (ST) on abaxial surface (AB), i.e., a lower surface, anisocytic (AN), guard cells (GS), 3 subsidiary cells (SC), i.e., 2 larger and 1 distinctly small.

Table 2. Powder analysis of a crude extract of *Enicostemma axillare*

Test reagent	Visible/Daylight			UV 254 nm (short)			UV 360 nm (long)		
	Leaves	**Stems**	**Roots**	**Leaves**	**Stems**	**Roots**	**Leaves**	**Stems**	**Roots**
PD	HG	*YG*	SY	NC	NC	NC	NC	NC	NC
PD in DW	HG	*YG*	SY	NC	NC	NC	NC	NC	NC
PA	CG	PY	LY	DG	LB	*G*	BL	*B*	*G*
Conc. H_2SO_4	PG	LB	DB	DG	DB	CB	BL	*G*	CB
Conc. HNO_3	*B*	Y	O	NC	YB	DY	NC	FG	DY
HCl	*LG*	Y	Y	DG	DG	GY	BL	BL	GY
AA	*LG*	Y	Y	DG	DG	GY	BL	BL	GY
LA	DG	*YG*	OY	NC	NC	Y	BLG	DG	Y
Iodine	*Pr*	YP	YP	BLG	*Pr*	YG	BLG	*Pr*	*YG*
FC	*G*	CB	YB	DB	DB	NC	BL	*G*	NC
Sudan III	*G*	R	SY	NC	*G*	GY	NC	*G*	GY
1N NaCl	*G*	Y	SY	DG	*YG*	Y	DG	*YG*	Y
1N NaOH	*YG*	YB	SY	NC	DG	*YG*	NC	DG	*YG*
1N HNO_3	*B*	Y	Y	BL	LG	*YG*	FG	LB	*YG*
Ammonia	*HG*	GY	SY	DG	DG	*LG*	DG	DG	*LG*
1N NaOH (Met)	DG	YB	YB	DB	BL	*B*	BLG	GW	*B*

Abbreviation: PD: powder, HG: henna green, YG: yellow-green, SY: straw yellow, NC: no change, DW: distilled water, PA: picric acid, CG: crystalline green, PY: pale yellow, LY: light yellow, DG: dark green, LB: light brown, G: green, BL: black, B: brown, Y: yellow, O: orange, YB: yellowish-brown, DY: dark yellow, LG: light green, GY: greenish-yellow, R: red, PG: pale green, DB: dark brown, CB: crystalline blue, FG: fluorescence green, BLG: blackish green, GW: Greenish white.

Table 3. The constant physical value of crude drugs

Parameter (ash values)	Values (%)		
	Leaves	**Stems**	**Roots**
Total ash	12.50	11.45	11.10
Water-soluble ash	5.30	4.25	6.52
Acid-insoluble ash	7.40	7.20	7.10
Acid soluble ash	6.10	5.25	5.00

This study observed prominent Enicostemma axillare to identify and authenticate true crude drugs and establish physicochemical parameters for screening commercial samples. The distinctive characters of the stem were the presence of parenchyma. Leaves microscopy indicates the presence of anisocytic stomata, minor leaf veins, phloem transfer cells, and numerous sclereids. Macroscopic study shows leaves with glabrous-surface, roots showed glabrous root surface, and stem was tall simple to branch and maybe prostrate or ascending. This sort of analysis by the micro and macroscopic parameters is easy to handle. It establishes the authenticity of the plant (WHO, 1998), and it's essential for the quality assessment of crude drugs (Luz et al., 2019). Color variation indicates the presence of different components and essential oils. The ash value includes a percentage of water-soluble, acid-soluble, and acid-insoluble ash values for leaf stem and root. These parameters are constant for the plant and can set a standard for screening (WHO 1996). This parameter establishes the inorganic content and adulterant present in crude drugs. It is also important for estimating and detecting salts, metals, and silica (Musa et al., 2006). The identification marks of crude drugs are essential for herbal medicines' efficacy, safety, and reproducibility (Nayak et al., 2010). The crude drug material sold in the commercial market is present in a very deformed state and with the naked eyes; it is hard to assure good quality, and in such cases, there are more chances of adulterations.

In summary, in the present study, we have found resourceful information about pharmacognostic characteristics and anatomical peculiarities of the Enicostemma axillare drugs to identify plants and their products to avoid adulterations with sub-standard products. Authentification is the first step towards ensuring the quality of starting material. Due to diminishing supply and overuse of raw drugs has become a dangerous problem in the Ayurvedic scenario. It would also help scientists utilize such needful information regarding the plant material identity. After thoroughly investigating, we concluded that the *Enicostemma axillare* is a commonly used medicinal plant. In macroscopic evaluation, we found a difference between fresh plant parts and dry plant parts like leaves, stems, and roots based on color, shape, and size. In Physical constant value determination, the ash values used to evaluate quality, authenticity, and purity of unsophisticated drugs and values obtained are necessary for quantitative standards. Efforts will be undertaken to continue Pharmacognostic studies and Anatomical peculiarities to avoid adulteration. There is insufficient evidence or detailed anatomical and physicochemical evaluation on *Enicostemma axillare*. Due to which present work is taken in the manner to completely standardize the herbs according to the standard laboratory procedure.

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Ethnobotanical indices on wound healing medicinal plants in the Arjuna River of Virudhunagar District in Tamil Nadu, Southern India

S. SHANMUGAM[1,♥], V. RAJAGOPAL[2], S. BALAMURUGAN[1], C.P. MUTHUPANDI[1], V.M. ESWARAN[3], K. RAVEENDRARETNAM[4], K. RAJENDRAN[1]
[1]Graduate and Research Department of Botany, Thiagarajar College. Madurai 625009, Tamil Nadu, India. Tel.: +91-9976595769, ♥email: shanmugambotany@gmail.com
[2]K.S.G. Government Higher Secondary School. Amathur, Virudhunagar 626005, Tamil Nadu, India
[3]Graduate and Research Department of Botany, The American College. Madurai 625002, Tamil Nadu, India
[4]Department of Botany, Sethupathy Government Arts College. Ramanathapuram 623502, Tamil Nadu, India

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Abstract. *Shanmugam S, Rajagopal V, Balamurugan S, Muthupandi CP, Eswaran VM, Raveendraretnam K, Rajendran K. 2021. Ethnobotanical indices on wound healing medicinal plants in the Arjuna River of Virudhunagar District in Tamil Nadu, Southern India. Asian J Ethnobiol 4: 31-36.* Medicinal plants can perform a significant role in preventing pathogenic attacks in the body. Plants are a great source of primary health care due to certain chemical compounds. Research on the traditional knowledge related to plants used for wound healing still needs adequate attention. The present study was carried out to document the therapeutic uses of medicinal plants in the Arjuna Riverbank of Virudhunagar District in Tamil Nadu to heal various wounds. The frequent fieldwork was conducted from June 2018 to March 2019 in four villages selected for this study. The scientific name, family name, local name (in Tamil), part (s) used, mode of preparation, method of application, and medicine administration were recorded. The ethnomedicinal data were statistically analyzed by ethnobotanical indices such as Use Value (UV), Citation Frequency (CF), and Relative Importance (RI). A total of 23 medicinal remedies prepared from 23 plants were recorded. *Mimosa pudica* was found with the highest values in all three indices. Further research on the phytochemistry and pharmacology of these medicinal plants should be conducted.

Keywords: Arjuna River, ethnobotanical indices, medicinal plants, wound heal

INTRODUCTION

Wounds are accidental physical damage to the body by loss of skin. Due to less hygienic situations, mostly in rural areas, the wound is a common disorder for skin problems (Senthil et al., 2006). The complete healing of wounds depends on the degree of injury, human resistance capacity, infection potential of pathogens, and early effective treatment procedure. Applying plants for wound control is a beneficial process for repairing skin. Due to the presence of antibiotic or antiseptic nature’s chemicals, plants are remarkable for the treatment of wounds (Kumarasamyraja et al., 2012).

Scrutinizing of the available sources was revealed that only a few monumental research works have been conducted on the ethnobotany of Virudhunagar District in Tamil Nadu (Arinathanet al. 2003; Muthukumarasamyet al. 2003a,b; Rajendran et al. 2004; Shanmugam et al. 2008). Having the facts mentioned above in mind, the present study is conducted to document the importance of medicinal plants in wound healing therapy among the local people living in and around the bank of the Arjuna River of Virudhunagar District.

MATERIALS AND METHODS

Study area

A total of four different study areas, i.e., Vadamalapuram-Aathupaalam, Vadamalapuram, Sorampatti, and Pethusettypatti, are located at the bank of Arjuna River, were selected to collect the ethnomedicinal information. The longitude and latitude of the study areas were as follow: (i) Vadamalapuram-Aathupaalam: 77º 80' 81'' E and 9º 48' 07'' N, (ii) Vadamalapuram: 77º 84' 10'' E and 9º 50' 51'' N, (iii) Sorampatti: 77º 85' 25'' E and 9º 50' 28'' N Latitude, (iv) Pethusettypatti: 77º 85' 43'' E and 9º 50' 17'' N. The altitudes of the study areas were about 90 – 107 m above mean sea level (MSL). All the study areas were located within 3.5 km; there was no fluctuation in temperature and rainfall. The temperatures of the study areas ranged from 20º to 41º C. The average annual rainfall reached 60-95 mm.

Data collection

Fieldworks were conducted frequently from June 2018 to March 2019. The ethnomedicinal data were collected following the methodology of Jain (1989), using direct field interviews with the herbal healers and non-herbal healers. A total of 11 informants (8 males and 3 females) were interviewed, and their current age, educational status, and occupation were also recorded. The information gathered was reconfirmed in other localities. The medicinal plants were botanically identified following the books of regional floras (Matthew 1983; 1991).

Ethnobotanical indices

Use Value (UV)

The importance of a medicinal plant was analyzed using Use Value (UV) for species I with the following formula: UVi = Ui / Ni. Where, Ui is the number of use-reports cited by each informant for a given plant species I, and Ni is the total number of informants interviewed for a given plant species I. Use value is high when there are many use-reports for a plant, and low when there are a few reports for a plant related to its use (Trotter and Logan 1986).

Citation Frequency (CF)

Citation Frequency was calculated as follows: CF = (Number of citations of a particular species mentioned / Total number of citations of all species mentioned) × 100. The CF is high when maximum informants quoted a species as medicine and low when less of them reproduced.

Relative Importance (RI)

Relative Importance was calculated with the following formula: RI = (RCF + RNU)/2. Where RCF is the relative citation frequency, it is obtained by the number of citations of a species dividing with the full citation of all species obtained (RCF = CF/max CF). RNU is the relative number of use categories; it is obtained by dividing the number of uses of the species by the maximum number of benefits of all species obtained (RNU = NU/max NU). THEORETICALLY, the RI index varies from 0, when nobody mentioned any plant use, to 1, when the plant was most frequently mentioned as medicine (Tardío and Pardo-De-Santayana 2008).

RESULTS AND DISCUSSION

Demographic profile of informants

The medicinal uses of plants were collected from 11 informants living in four different localities situated at the bank of the Arjuna River to predict and define the exact nature of the traditional knowledge on medicinal plants utilized to treat the wound. The number and percentage of informants in terms of age category, age at becoming healers, educational status, and occupation are provided in Table 1.

Medicinal plants for wound healing

This study recorded 23 medicinal remedies prepared from 23 plants to treat various wounds. Out of 23 plants, 21 species were used to treat common injuries, one species to cure chronic wounds, and one species for mouth wounds (Table 2). It was noted that the 23 species belonged to 23 genera and 19 families (Table 3). Among the 23 species recorded, dicots were represented by 18 species belonging to 18 genera and 14 families, while monocots were five species belonging to five genera and five families (Table 3). Caesalpiniaceae was the dominant family and contributed to wound healing with 3 species. Euphorbiaceae and Mimosaceae were represented by two species each, and the remaining 16 families were recorded with single species only (Table 4). The entire reported genera were found as mono-specific (Table 2).

Life form

According to species' life form, most of the plants were herbs (12 species), followed by trees (6 species) and shrubs (4 species). Only one climber species was obtained (Table 2; Table 5). The previous ethnobotanical studies conducted in various regions of Tamil Nadu have strongly evidenced that herbs possessed the medicinal values than other life forms (Shanmugam et al. 2008; Sankaranarayanan et al. 2010; Rajalakshmi et al. 2016; Jespin Ida and Augustus Arul 2016). The frequent use of herbs by the informants is a result of occurring herbaceous plants in their surrounding environments.

Table 1. Number and Percentage (in parenthesis) of informants based on their basic profiles

Basic profiles	Non-Herbal healers			Herbal healers			Total informants		
	Male (*n* = 5)	Female (*n* = 2)	Total (*n* = 7)	Male (*n* = 3)	Female (*n* = 1)	Total (*n* = 4)	Male (*n* = 8)	Female (*n* = 3)	Total (*n* = 11)
Current age									
< 40 years	1 (20.0)	0	1 (14.28)	0	0	0	1 (12.5)	0	1 (9.10)
41 – 60 years	3 (60.0)	1 (50.0)	4 (57.14)	1 (33.33)	0	1 (25.0)	5 (62.5)	1 (33.33)	6 (54.54)
> 60 years	1 (20.0)	1 (50.0)	2 (28.58)	2 (66.67)	1 (100)	3 (75.0)	2 (25.0)	2 (66.67)	4 (36.36)
Age at becoming healers									
Below 30 years	–	–	–	1 (33.33)	0	1 (25.0)	1 (12.5)	0	1 (9.10)
Above 30 years	–	–	–	2 (66.67)	1 (100)	3 (75.0)	2 (25.0)	1 (33.33)	3 (27.27)
Education									
Literate	4 (80.0)	1 (50.0)	5 (71.42)	1 (33.33)	0	1 (25.0)	5 (62.5)	1 (33.33)	6 (54.54)
Illiterate	1 (20.0)	1 (50.0)	2 (28.58)	2 (66.67)	1 (100)	3 (75.0)	3 (37.5)	2 (66.67)	5 (45.46)
Occupation									
Farmer	3 (60.0)	0	3 (42.86)	2 (66.67)	0	2 (50.0)	5 (62.5)	0	5 (45.46)
Cattleman	1 (20.0)	2 (100.0)	3 (42.86)	1 (33.33)	1 (100)	2 (50.0)	2 (25.0)	3 (100.0)	5 (45.46)
Agriculture laborer	1 (20.0)	0	1 (14.28)	0	0	0	1 (12.5)	0	1 (9.08)

Table 2. List of ethnomedicinal plants used for wound healing

Botanical name	Family name	Vernacular name (Tamil)	Habit	IUCN status*	Medicinal use	UR	UV	CF	RI
Acacia leucophloea (Roxb.) Willd.	Mimosaceae	Velvaelam	Tree	NE	Stem bark paste is applied to heal the wound	5	0.45	4.95	0.75
Aponogeton natans (L.) Engler & K.Krause	Aponogetonaceae	Kottaikkizhangu	Herb	LC	The wound caused by heat is treated with entire plant extract	3	0.27	2.97	0.65
Bauhinia variegata (L.) Benth.	Caesalpiniaceae	Mandhaarai	Tree	LC	Leaf paste is applied to treat the wound	4	0.36	3.96	0.70
Bergia ammannioides Roxb.	Elatinaceae	Neervaatti	Herb	NE	Leaf paste is applied to cure the wound	2	0.18	1.98	0.60
Cleome viscosa L.	Capparidaceae	Naaikkadugu	Herb	NE	Leaf paste is applied to heal the wound	6	0.54	5.94	0.80
Cocos nucifera L.	Arecaceae	Thennai	Tree	NE	Oil extracted from the fruit is applied to heal the wound	9	0.81	8.91	0.95
Croton bonplandianum Baill.	Euphorbiaceae	Vettukkaayappoondu	Herb	NE	Stem latex is applied to heal the wound	8	0.72	7.92	0.90
Cyperus articulatus L.	Cyperaceae	Korai	Herb	LC	Leaf paste is applied to heal the wound	5	0.45	4.95	0.75
Euphorbia cyathophora Murray	Euphorbiaceae	Paalperukki	Shrub	NE	Leaf latex is applied to treat the wound	1	0.09	0.99	0.55
Heliotropium indicum L.	Boraginaceae	Thealkodukku	Herb	LC	Entire plant paste is applied to treat the wound	4	0.36	3.96	0.70
Hydrilla verticillata (L.f.) Royle	Hydrocharitaceae	Kodippaasi	Herb	NE	Entire plant paste is applied externally to heal the wound	2	0.18	1.98	0.60
Hydrolea zeylanica (L.) Vahl	Hydrophyllaceae	Ponnaangannichakkalathi	Herb	NE	Entire plant paste is applied with coconut oil to heal the wound	2	0.18	1.98	0.60
Ipomoea carnea Jacq.	Convolvulaceae	Urachedi	Shrub	NE	Leaf paste is applied to heal the wound	4	0.36	3.96	0.70
Lawsonia inermis L.	Lythraceae	Maruthaani	Tree	NE	Leaf powder is mixed with coconut oil and applied to treat the wound	6	0.54	5.94	0.80
Luffa cylindrica (L.) M.Roem.	Cucurbitaceae	Soppukkaai	Climber	NE	Leaf paste mixed with turmeric powder are applied to heal the wound	1	0.09	0.99	0.55
Mimosa pudica L.	Mimosaceae	Thottaalsurungi	Herb	LC	Leaf paste is applied to treat the wound	10	0.90	9.90	1.0
Senna alata L.	Caesalpiniaceae	Seemaiagathi	Shrub	NE	Paste of flower is applied to cure the wound	4	0.36	3.96	0.70
Sida acuta Burm. f.	Malvaceae	Arivaalmanaipoondu	Herb	NE	Leaf paste is applied to heal the wound	3	0.27	2.97	0.65
Stachytarpheta jamaicensis (L.) Vahl	Verbenaceae	Seemainaayuruvi	Herb	NE	Stem paste is applied to heal the wound	3	0.27	2.97	0.65
Tamarindus indica L.	Caesalpiniaceae	Puli	Tree	LC	Stem bark paste is applied to treat the chronic wound	5	0.45	4.95	0.75
Tridax procumbens L.	Asteraceae	Thaathaappoo	Herb	NE	Entire plant paste is applied to treat the wound	7	0.63	6.93	0.85
Typha angustifolia L.	Typhaceae	Sambai	Shrub	NE	Leaf juice is gargled to cure the mouth wound	4	0.36	3.96	0.70
Ziziphus mauritiana Lam.	Rhamnaceae	Yilandhai	Tree	NE	Stem bark powder is applied to heal the wound	3	0.27	2.97	0.65

Abbreviations: *NE: Not Evaluated; LC: Least Concerned; UR: Use Reports; UV: Use Value; CF: Citation Frequency; RI: Relative Importance

Table 3. Species distribution in different taxa

Taxa	Dicot	Monocot	Total
Species	18	5	23
Genus	18	5	23
Family	14	5	19

Table 4. List of families with several genus and species

Family name	No. of genus	No. of species
Aponogetonaceae#	1	1
Arecaceae#	1	1
Asteraceae	1	1
Boraginaceae	1	1
Caesalpiniaceae	3	3
Capparidaceae	1	1
Convolvulaceae	1	1
Cucurbitaceae	1	1
Cyperaceae#	1	1
Elatinaceae	1	1
Euphorbiaceae	2	2
Hydrocharitaceae#	1	1
Hydrophyllaceae	1	1
Lythraceae	1	1
Malvaceae	1	1
Mimosaceae	2	2
Rhamnaceae	1	1
Typhaceae#	1	1
Verbenaceae	1	1
Total	23	23

Notes: #Monocot families; Others are dicot

Table 5. Species distribution in different life forms

Life form	Dicot	Monocot	Total
Climber	1	0	1
Herb	9	3	12
Shrub	3	1	4
Tree	5	1	6

Parts used

In the case of plant parts used, the leaf was the most used plant part in 11 preparations with 47.82% to treat the wound, followed by the whole plant in five preparations with 21.74%, stem bark in three preparations with 13.04%, and stem in two practices with 8.70%. Flower and fruit were the least used parts in one preparation with 4.35% each (Figure 1).

The results are in line with the findings of many monumental studies carried out in different localities of Tamil Nadu, and they showed that leaves were frequently used plant part (Kottaimuthu 2008; Shanmugam et al. 2008; Vanila et al. 2008; Shanmugam et al. 2011a; 2011b; 2012a; 2012b; Jeyakumar et al. 2014; Kathirvelmurugan et al. 2014; Disticraj and Jayaraman 2015; Krishnamoorthy et al. 2015; Prabhu and Vijayakumar 2016). The reason behind the extensive use of leaves is, they are active in photosynthesis which leads to the production of secondary metabolites in high concentration when compared to other parts of the plant, and these metabolites are actively implicated in remedial activity (Ghorbani 2005; Shanmugam et al. 2007; Ayyanar et al. 2008).

Mode of preparation

The informants prepared and prescribed the medicine mainly in the form of paste (69.55%), followed by latex (8.70%), and powder (8.70%). The slightest use was recorded for extract, juice, and oil (0.45% each) (Figure 2). The following reasons might cause these findings: while preparing the medicine as a paste, in most cases, it does not need water for the preparation and, if water is added, the therapeutic properties will become deluded, as in the case of infusion and juice preparations. Meanwhile, the active secondary metabolites in the plant used to treat particular ailments are involved in the anti-disease activity.

Mode of administration

Among the medicinal remedies recorded from the informants, the standard method of medicinal administration route was applied for the medicine topically (91.30%). Some preparations were taken through the following ways: the medicinal preparation was used as washed and gargled (4.35% each) (Figure 3). These observations follow the results of most of the previous studies conducted in Tamil Nadu (Sandhya et al. 2006; Shanmugam et al. 2009; Pandikumar et al. 2011; Ganesh et al. 2016).

Use of medicine with ingredients

In general, the healers in the present study area prepared the medicine from a single plant. In a few cases, they designed the treatment and other plant products. For example, whole plant paste of *Hydrolea zeylanica* is mixed with coconut oil and applied, leaf powder of *Lawsonia inermis* is mixed with coconut oil and used, and leaf paste of *Luffa cylindrica* is mixed with turmeric powder and applied to treat wound (Table 2).

The frequent use of multiple plant products and other materials could be attributed to synergic reactions among the traditional healers (Giday et al., 2010). It is also believed that the multi-herbal treatment has more healing power than that of a single plant (Teklehaymanot and Giday 2007; Shanmugam et al. 2020).

Conservation status

According to IUCN conservation status (IUCN 2020), it was noted that the Arjuna River harbors six Least Concerned (LC) plants, i.e., *Aponogeton natans*, *Bauhinia variegata*, *Cyperus articulates*, *Heliotropium indicum*, *Mimosa pudica*, and *Tamarindus indica*, and the remaining species were under Not Evaluated (NE) category (Table 1).

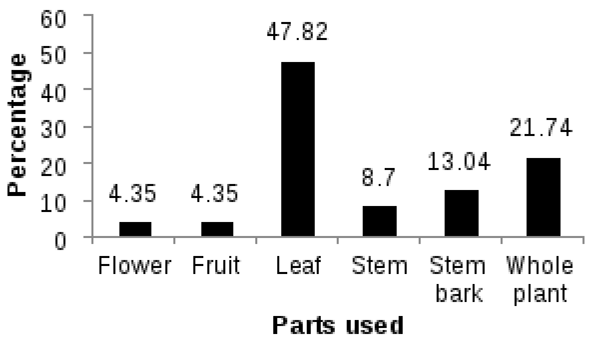

Figure 1. Percentage of plant parts used

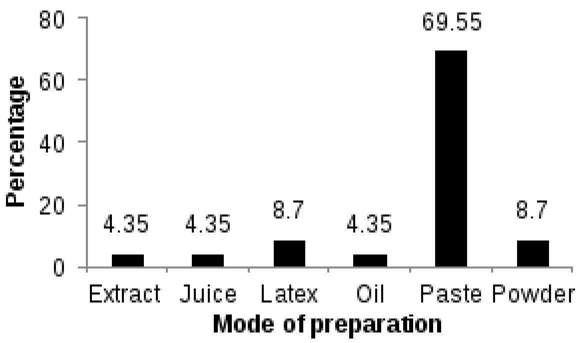

Figure 2. Percentage of the mode of preparation

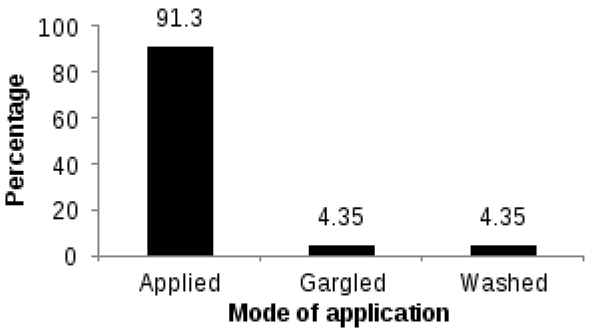

Figure 3. Percentage of the mode of application

Ethnobotanical indices

Use value (UV)

Use values are high when there are many valuable reports for a plant and low when few reports are related to its use (Trotter and Logan 1986). According to the UV analysis, the most frequently used species to heal the wound in the study area was *Mimosa pudica* (UV: 0.90, use reports: 9), followed by *Cocos nucifera* (0.81, 9), *Croton bonplandianum* (0.72, 8), *Tridax procumbens* (0.63, 7), *Cleome viscosa* (0.54, 6) and *Lawsonia inermis* (0.54, 6). The least frequently used species were *Euphorbia cyathophora* and *Luffa cylindrica* (UV: 0.09 with a single-use report each) (Table 1). The highest use values shown by some medicinal plants indicated that these species are highly preferred to heal various types of wounds. The low UV is due to the less effective use of particular species in the study area.

Citation Frequency (CF) and Relative Importance (RI)

In the present study, CF values ranged from 0.99 to 9.90, and RI ranged from 0.55 to 1.0 (Table 2). The highest value was recorded for *Mimosa pudica* (CF: 9.90, RI: 1.0), followed by *Cocos nucifera* (8.91, 0.95), *Croton bonplandianum* (7.92, 0.90), *Tridax procumbens* (6.93, 0.85), *Cleome viscosa* (5.94, 0.80), and *Lawsonia inermis* (5.94, 0.80), while the lowest values of CF: 0.99 and RI: 0.55 were recorded for *Euphorbia cyathophora* and *Luffa cylindrica* each (Table 2). The plants with high CF and RI values indicated their multi-use, widely known local communities, and abundantly distributed. The local communities collected the plants from the wild habitat and cultivated some adjacent to homes, churches, and pagodas for their immediate need.

Pharmacological evidence

Previous studies that examined the wound healing potential of some plants recorded in the present study are as follows: Neto et al. (2011) evaluated the wound healing potential of lectin and its recombinant isoform extracted from *Bauhinia variegata* on mice, and the study indicated that the phytoconstituents possess healing properties and may be employed in the treatment of acute skin wounds. Panduraju et al. (2011) reported that Isoliquiritigenin, a natural phenol isolated from *Cleome viscosa* as an antitumor promoter, and the ethanolic extract of this plant showed significant wound healing activity. Likewise, some other studies also confirmed the wound healing potential of aqueous extract of *Ipomoea carnea* (Khalid et al. 2011), ethanolic extract of *Lawsonia inermis* (Kaur et al. 2014), and ethyl acetate extract of *Tridax procumbens* (Abubakar et al. 2012) in clinical trials by using animal models.

In conclusion, human clinical experiments should be conducted on these plants to prove their pharmacological efficacies related to wound healing potential. Phytochemical and pharmacological values of all these medicinally important plants should be tested, which ultimately leads to a new drug's birth. Attention should also be made to proper exploitation and utilization of these plants; otherwise, there will be the possibility of extinction of particular species in the future.

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Short Communication: *Jagal*, a traditional health food at Khadi Fair in Udaipur, Rajasthan, India

VARTIKA JAIN
Department of Botany, Government Meera Girls' College. Udaipur-313001, Rajasthan, India.
Tel.: +91-9460084200, email: vartikabotany@gmail.com

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Abstract. *Jain V. 2021. Short Communication: Jagal, a traditional health food at Khadi fair in Udaipur, Rajasthan, India. Asian J Ethnobiol 4: 37-41.* Fairs and festivals are important to reflect traditional knowledge about various cultural, dietary, and healthcare practices. India has a rich legacy of cultural diversity, confluent in cuisine diversity. Every year, Rajasthan Khadi and Village Industries Board organizes the Khadi fair in different districts of Rajasthan to exhibit and sell the products developed by artisans and local people of the state. Ethnobotanical surveys of the Khadi fair held at Udaipur city, Rajasthan, were carried out for the first time to document traditional health food items being sold in the fair. Semi-structured interviews conducted with sellers and consumers in the surveys revealed the mode of preparation, rate, and intended use of a hitherto unreported traditional health food locally called '*Jagal*.' It is a plant-based product developed mainly from sesame seeds, dried coconut kernel, and jaggery and consumed as a nutritious health food by urban mass and as a reliever of joint and back pain in older adults. Detailed scientific assessment of nutritional and therapeutic benefits of '*Jagal*' needs to promote this food on international canvas as a dietary nutraceutical.

Keywords: Coconut, fair, jaggery, joint pain, nutraceutical, sesame

INTRODUCTION

India is a land of diverse ethnic communities that utilize nearby growing biodiversity to fulfill daily needs and perform many socio-cultural rituals and customs (Jain 1999; Jain and Jain 2016). Rajasthan is India's largest state, covering 10.4% of the total geographical area, having rich floristic and ethnic diversity. Local people utilize many plant species in Rajasthan as dietary therapeutic agents. Efforts have been made to document traditional knowledge about those medicinal dietary recipes in the region (Katewa and Jain 2006). Yet, exhaustive ethnobotanical explorations are still required to gather information about traditional and indigenous knowledge dimensions scattered among various parts of the state. Udaipur is a tribal-dominated district situated in the southern part of Rajasthan. The Aravalli hills surround it with a rich flora creating much scope for ethnobotanical studies (Tiagi and Aery 2007; Katewa and Jain 2006).

The use of food as a therapeutic agent in the diet is part of many cultures, and edible plants having healing properties are one of the most utilized foods for this purpose since ancient times. A rich wealth of traditional knowledge associated with plants which include certain food products in diets to preserve health, exists among indigenous communities. These healthy diet recipes are inculcated among them traditionally. Several Ethnobotanists worldwide are exploring this arena to demonstrate the concept of food as medicine and medicine as food' prevailing among various ethnic communities (Bhat 2012; Pieroni and Price 2006; Etkin and Ross 1982; Johns 1999).

The interdisciplinary nature of Ethnobotany is reflected in the cultural integration of plants in fairs, festivals, worship, ornamentation, paintings, proverbs, personal names, etcetera (Jain 2017a). Fairs and festivals are part of Indian cultural heritage and display various products and activities. Some of the fairs are organized for religious reasons, some on the arrival of new seasons, and some say multiple artifacts made by local artisans (Jain 2016, 2017b).

Rajasthan Khadi Ghramodyogh Board (Rajasthan Khadi and Village Industries Board- RKVIB) is a state setup working under Khadi & Village Industries Commission (KVIC) which is an initiative under the Ministry of Micro, Small and Medium Enterprises, Govt. of India for the promotion of Khadi clothes all over the country (Website 1). Khadi is a handspun and hand-woven cloth made famous by M.K. Gandhi for self-reliance and economic upliftment of rural people of India (Website 2). RKVIB organizes a Khadi fair in December at Udaipur, Rajasthan, for a fortnight. Various products of Khadi and products developed by multiple small-scale villages industries are exhibited for sale. These products include clothes made from Khadi cotton, silk, and wool in sarees, bedsheets, shawls, woolen jackets, caps, towels, etc. Besides, herbal medicines, cosmetics, honey, homemade pickles, snacks like 'papad,' 'namkeen,' and traditional food items prepared by local people are also sold at the fair.

Documentation of traditional dietary healthcare practices at fairs can help develop nutraceutical products.

For this purpose, ethnobotanical surveys were carried out in Khadi fair held at Nagar Nigam Prangan, Town Hall at Udaipur city, India in December 2018, first documented

MATERIALS AND METHODS

Study area

Udaipur district, earlier known as 'Mewar' region, is bounded by Rajsamand district in North, Chittorgarh, and Pratapgarh districts in East, Sirohi and Pali districts in West and Dungarpur district in South. It has a total area of 11,724 square kilometers with an urban population of 60,8426 residents. There are 11 tehsils in Udaipur city, having 2,479 villages with a rural population of 245,9994 people. It possesses a total Scheduled Tribe (ST) population of 152,5289, which is 49.7% of the total ST population (13.5%) of the state (Census of India 2011). Bhil, Garasia, Kathodi, Damor, and Meena are a few main tribes dwelling in Udaipur city. It possesses mainly dry deciduous forests (Tiagi and Aery 2007).

Collection of data

For this purpose, all the stalls of the Khadi fair held at Udaipur were visited for five days at different times in a day, and it was found that a traditional health food called '*Jagal*' was being sold at five stalls in the fair. Each of those five stalls was managed by one male and one female between 25-40 years. These ten sellers came from a nearby rural Udaipur city (Girwa, Vallabhnagar, and Mavli tehsils).

Information about '*Jagal*,' preparation technique, ingredients, their local names and procurement regions, quantity recommended for consumption, selling rates, and uses and therapeutic benefits associated with its consumption was collected from those sellers via semi-structured questionnaires considering them as qualified informants. Photographs of the ingredients of '*Jagal*' were taken, and its preparation process was noted down with the consent of the sellers.

Moreover, the perception of 25 consumers, aged 25-75 years (five each from those five stalls in a day) who were willing to participate in the survey, irrespective of their gender, caste, religion, and education, was also noted down about the efficacy and reasons behind purchasing of '*Jagal*.' All the interviews were conducted in the Hindi language. Prior informed consent was always obtained verbally before interviewing each informant.

Correct scientific names and family of plant ingredients of '*Jagal*' are given in the Results, which was ascertained with the help of details provided in Flora and other relevant literature (Tiagi and Aery 2007; Jain and Jain 2018; The Wealth of India 1972). Recent scientific nomenclature was adopted for the botanical identities of plant materials (www.theplantlist.org).

RESULTS AND DISCUSSION

India has witnessed wide diversity in cuisine, ingredients, preparation, and processing techniques established over many generations. Many of the traditional foods in the country are also known for their therapeutic effects. They could be called functional foods or nutraceuticals by providing nutrition and pharmaceutical actions (Sarkar et al., 2015). Therefore, documentation of traditional knowledge about ethnic food is helpful for health-conscious citizens globally, and in this regard, the present study keeps the significance as a small effort.

The survey revealed that besides the popular winter sweets 'Gajak' and 'Rewri' (Jain 2020), five stalls were selling a hitherto unreported traditional health food product '*Jagal*' at the rate of Rs. 300/- per kg in Khadi fair (Figs. 1-6). '*Jagal*' is a food product having semi-solid consistency and consists of three primary ingredients which are, 'Til' (Sesame): seeds of *Sesamum indicum* L. (Pedaliaceae), 'Khopra' (Coconut): dried endosperm of *Cocos nucifera* L. (Arecaceae) and 'Gur' (Jaggery) developed from stem juice of *Saccharum officinarum* L. (Poaceae). Local names of these plant ingredients are mentioned in a single high-reversed-9 quotation mark. The interesting observation was that these three ingredients were being mixed in a ratio of 2: 0.5: 1.5 respectively, one after another in an electric power based '*Ghani*'- a machine in which these ingredients were poured in the circular mortar and crushed by electric driven pestle (Figures 2-3). After that, small pieces of different dry nuts such as Almonds (*Prunus dulcis* D.A. Webb), Cashew nut (*Anacardium occidentale* L), Pistachio (*Pistacia vera* L.) as well as Raisins (*Vitis vinifera* L.) and Muskmelon (*Cucumis melo* L.) seeds were added to it, and '*Jagal*' was ready for consumption. Higher rates of Rs. 500/- per kg were observed for '*Jagal*' mixed with more quantities of dry nuts.

White and Black Sesame seeds were used on two stalls to make 'Jagal' (Figures 5-6). The rate of '*Jagal*' made from black Sesame seeds was comparatively higher than '*Jagal*' made from white Sesame seeds, *i.e.*, Rs. 400/-per kg. Except for sesame, dry nuts and coconut were procured from other parts of the country due to unsuitable climatic conditions of Rajasthan.

Markets are effective means for exchanging cultural information and selling several products. They have been the object of ethnobotanical studies worldwide, and exciting data have been retrieved (Padoch 1988; Pochettino et al. 2012). Similarly, Fairs also provide space for many rural and local people to exhibit their traditional art, craft, and culinary skills (Jain 2017b). In the present survey, both males and females managed the stalls and came from villages located within 20-50 km periphery of Udaipur. Sellers also informed that the recipe of '*Jagal*' is known to them through their elders as they used to consume this product in winters and are selling it in urban areas. This depicts the transmission of traditional knowledge from the elderly to the young generation of the rural regions and then to urban areas through these kinds of fairs and demonstrates the importance of holding such fairs in pluricultural urban areas to provide access to various traditional products not frequently available in cities. The organization of fairs in urban areas is also important for providing a platform for rural people to demonstrate their skills, promote traditional culture, and generate additional income. However, reasons for the temporary migration of rural people to urban areas need to be searched through intensive urban ethnobotanical studies (Hurell and Pochettino 2014).

'*Ghani*' represents traditional oilseed milling technology with a circular mortar and good pestle, which moves with the movement of animals in a circular ambit so that oil comes out of seeds. Regional variations could be observed in the 'Ghani' design depending on oilseeds available in a particular region (Patel 1943; Chaudhuri and Selvaraj 1985). Nowadays, these animal-driven traditional '*Ghani*s' are replaced mainly by electric power-based '*Ghani's*.' In the present survey, all five stalls used these electric 'Ghanis' to make '*Jagal*' (Figure 1). Besides, they were also selling Sesame oil (extracted through these '*Ghani*s') at the rate of Rs. 200/- per liter (Figure 4).

Sellers recommended daily consumption of at least 100 g of '*Jagal*' for a week for an adult person and suggested not taking water after half an hour of its consumption. This food is especially beneficial for people with joint pain, back pain, weak bones, or rheumatoid arthritis illnesses. Further, they informed that its consumption generates heat in the body, which is beneficial in tolerating cold. Therefore, they suggested it be consumed as a health vitalizing food in the winter season. They further informed that it remains fresh for 10 days if kept outside at room temperature in the cold winter season of December.

It was observed that consumers were readily purchasing '*Jagal*,' and some were consuming it on-site, and some were getting it packed for daily use at home. All the interviewed consumers affirmatively responded to the efficacy of '*Jagal*' as claimed by sellers. In December, the peak cold season in Udaipur, '*Jagal*' is one of the best nutritious food items to combat extreme low temperatures of 1-4° C. This might be due to the high calorific value of its ingredients. Out of 25, eight elderly consumers having joint and back pain responded positively in reducing these troubles after consuming '*Jagal*' daily for a week, highlighting the role of '*Jagal*' as food and medicine. There were mainly three reasons for purchasing '*Jagal*.' First, consumers could not prepare this food at home; second, its associated health benefits; third, its traditional recommendation by elders compelled them to purchase this food every year from the fair.

Medicinal properties of plant ingredients

Fat-rich Sesame is also known as the 'Queen of oil seeds.' In scientific studies, sesame has also demonstrated various health-beneficial activities such as antioxidant, antimicrobial, anti-inflammatory, anti-diabetic, anticancer, anti-hyperlipidemic, hepatoprotective, and anthelmintic anti-leishmanial, gastro-protective, and vasorelaxant. Sesame oil contains the furofuran lignan sesamin and analog sesamolin with antioxidant properties that help inhibit cholesterol biosynthesis and tocopherol metabolism and excretion. Its seeds are rich in protein content with amino acids such as methionine and tryptophan. Given its therapeutic potential against metabolic, inflammatory, and infectious diseases, it can be considered beneficial for human consumption (The Wealth of India 1972; Moazzami and Kamal-Eldin 2009; Amoo et al. 2017). Moreover, informants also said that 'Jagal' made from black Sesame seeds provides more health benefits than white Sesame seeds. However, they were unaware of both seedlings' comparative scientific chemical composition. This seems correct when calcium and phosphorus contents are compared, which are more in black Sesame seeds. The high calcium content might be the reason behind the improved bone health of older adults.

Coconut has a long history of use as food and medicine. In various scientific studies, the dried kernel has demonstrated antioxidant, antimicrobial, antimalarial, antihypertensive, and anti-diabetic properties. Coconut oil obtained from 'Khopra' is rich in saturated fatty acids such as Lauric and Myristic acid and shown to have an anti-thrombotic effect by lowering tissue plasminogen activator and lipoprotein(a) concentration (Lima et al. 2015; Mandal and Mandal 2011; Müller et al. 2003). This property is, in fact, very significant in reducing the risk of a heart attack which is the primary cause of deaths during the winter season (Fares 2013). This might be another scientific reason confirming consumption of '*Jagal*' during winters as a healthy option. Most of the nuts used in '*Jagal*' are rich in mono- and poly-unsaturated fatty acids and have been shown to lower the risk of cardiovascular, diabetes, cancer, etc. (Sabaté and Ang 2009; Falasca et al. 2014). Therefore, their addition to '*Jagal*' makes it healthier food.

Another essential ingredient of '*Jagal*' is the traditional sweetener 'Jaggery' obtained from Sugarcane juice. It is regarded as a medicinal and nutritious sweetener due to its various health benefits and vitality-enhancing properties in man. *Susurta samhita* mentions its highly nutritious properties and effectiveness in rheumatic afflictions and disorders of bile. It is a rich source of iron with other minerals such as calcium, phosphorus, thiamine, and nicotinic acid. It is also helpful in alleviating the harmful effects of arsenic and silicosis (Rao et al., 2007; Moses et al., 2012). Its cytoprotective, antioxidant, and anti-carcinogenic potential has also been demonstrated by Nayaka et al. (2009). Given this scientific evidence and chemical composition studies, it could be said that ingredients of '*Jagal*,'' mainly Sesame and Jaggery are behind the improvement in joint pain and bone health as affirmed by the consumers of the present study. However, a detailed scientific assessment of the nutritional and medicinal qualities of '*Jagal*' is required to establish its role as a healthy food.

Figure 1. A. Electric *ghani*, B. Milling sesame seed in *Ghani*, C. Mixing of jaggery, D. Selling of *jagal* in the fair, E. *Jagal* prepared from white sesame seeds, F. *Jagal* prepared from black sesame seeds

Traditional food recipes play a vital role in the well-being of indigenous communities worldwide. The interest has been developed worldwide to find healthy dietary products to combat diseases arising from an unhealthy lifestyle, synthetic chemical-rich edibles, and polluted air (Milburn 2004). In this regard, documentation of traditional health foods is an urgent need. The paper documents traditional knowledge about healthy food products being sold at the Khadi fair at Udaipur and reveals '*Jagal*' as a traditional health recipe. However, scientifically rigorous ethnobotanical surveys about '*Jagal*' from urban and rural socio-culturally heterogeneous communities and scientific validation of health benefits of this traditional food are recommended. This preliminary survey may help recognize this traditional hitherto unreported health food product as a dietary nutraceutical on the international canvas. Further marketing strategies at a large scale could create employment opportunities leading towards the sellers' enhanced income, thereby improving their socio-economic status. Similar studies of fairs organized under the banner of KVIC in other states of the country could lead towards documentation of other important indigenous practices.

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Ethnobotanical study of medicinal plants used to treat human diseases in Gura Damole District, Bale Zone, Southeast Ethiopia

BEHAILU ASSEFA[1], MOA MEGERSA[1,♥], TILAHUN TOLOSSA JIMA[2]
[1]Department of Biology, School of Natural Science, Maddawalabu University. P.O. Box 247, Robe, Ethiopia. ♥email: moamegersa78@gmail.com
[2]Department of Biology, College of Natural and Computational Sciences, Ambo University. P.O. Box 19, Ambo, Ethiopia

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Abstract. *Assefa B, Megersa M, Jima TT. 2021. Ethnobotanical study of medicinal plants used to treat human diseases in Gura Damole District, Bale Zone, Southeast Ethiopia. Asian J Ethnobiol 4: 42-52.* Many countries, including Ethiopia, use medicinal plants for their primary health care system. Plants have been used as a source of medicine to treat human diseases in Ethiopia. This study aimed to document medicinal plants to treat various human diseases in southeast Ethiopia's, the Gura Damole District of Oromia Regional State. Ethnobotanical survey of medicinal plants was carried out from August 05 to November 06, 2019. A total of 90 informants were selected to collect ethnobotanical information from 6 kebeles. Ethnobotanical data were collected using semi-structured interviews, focus group discussions with informants, and field observation. Various ethnobotanical ranking indices were used to analyze the importance of some plant species. A total of 30 medicinal plants belonging to 21 families were identified. These medicinal plants comprised shrubs (36.6%), trees (26.6%), herbs (23.3%), and lianas (13.3%). The plant families with the highest medicinal plants in the study area used for various diseases treatment were Asteraceae and Solanaceae (3 species each). Leaves (46.7%) were the dominant plant part used to prepare remedies, followed by roots (36.7%). Powdering (50%) and oral route of administration (59%) were commonly mentioned methods of preparation and administration, respectively. *Carissa spinarum* was the most preferred medicinal plant to treat evil eyes and is also ranked highest as the preferable medicinal plant for various purposes. Although the current study revealed the existence of indigenous knowledge of medicinal plants to treat human diseases, agricultural expansion became the primary threat to medicinal plants. Hence, different conservation methods should be applied to conserve those mostly preferred and frequently used medicinal plants for various purposes.

Keywords: Gura Damole, indigenous knowledge, medicinal plants, preparations, traditional medicine

INTRODUCTION

People in many parts of the world use medicinal plants as traditional treatments for various human ailments (Palombo 2011). According to the World Health Organization, between 65% and 80% of the world's population use medicinal plants as remedies (WHO 2011). The use of traditional medicine continues to expand rapidly across the globe (Kumar et al., 2013). According to the WHO, around 21,000 plant species can potentially be used as medicinal plants (Lucy and Edgar 1999).

In Africa, up to 80% of the population relies on medicinal plants for primary healthcare (WHO 2002). The population's dependence on traditional medicine is linked with poverty, inadequate health services, and a shortage of drugs (Birhan et al., 2011; Agbor and Nidoo, 2015). Local people of Ethiopia use traditional medicinal plants to get relief from numerous diseases. Nearly 80% of the Ethiopian population use traditional remedies, of which about 95% of the preparations are of plant origin (Abebe et al. 2001). To assess the medicinal values of these plants, various ethnobotanical studies have been conducted in Ethiopia. Most of the studies were carried out in the Oromia, South Nation and Nationalities of Peoples (SNNP), and Amhara regions (Alebie et al. 2017; Muluye and Ayicheh 2020). However, the reported medicinal plants are still minimal compared with Ethiopia's multi-cultural and floral diversity (Bekele and Reddy 2015; Chekole 2017). The ethnomedicinal knowledge varies even in the same ethnic group as various authors reported different medicinal plants and use. For instance, in the Oromo ethnic group of Ethiopia, other research groups said diverse use of medicinal plants to cure their ailments. Among the studies on medicinal plants used for human diseases treatment in the Oromia region include; Lulekal et al. (2008) in Mana Angetu district, Demie et al. (2018) in Dirre Sheik Hussen, Jima and Megersa (2018), Barbare district, Yineger and Yewhalaw (2007) in Sokoru district.

These studies reported a remarkable number of medicinal plants used by local communities for their primary healthcare. However, the disinterest of the young generation in indigenous knowledge, various threats, and minimal effort of conservation became significant concerns of medicinal plants (Yineger and Yewhalaw 2007; Jima and Megersa 2018). The knowledge of medicinal plants is transferred orally, and essential information on plants is discarded in the process (Kassa et al. 2020).

Like other communities living in different parts of Ethiopia, local people living in Gura Damole District use many plant species in human disease treatments. However, the knowledge vanished before proper documentation, as various studies evidenced. Therefore, the first objective of this research was to document medicinal plants and associated indigenous knowledge of the local people of the

Gura Damole district. Second, the study aimed to assess threats to medicinal plants of the study area. The findings of this study may serve as a stepping stone for further phytochemical and pharmacological studies.

MATERIALS AND METHODS

Description of the study area

From August 5 to November 6, 2019, the study was conducted in Gura Damole District, Bale Zone, Oromia Regional State, Southeast Ethiopia. Gura Damole district (07°05' N and 40° 12'E) is located about 575 km from the capital city, Addis Ababa. The district possesses a total population of 38,125, of whom 19,479 are male and 18,646 female (CSA 2007). The altitude range is 900 to 2200 m a.s.l Gura Damole District Agricultural Office (GDDAO 2019). The annual mean temperature and rainfall are 22 °C, and 1600 mm, respectively. Gura Damole district possesses two major rainy seasons: autumn (‘Arfasa’) in Afaan Oromo, which extends from September to February, and winter (‘Genna’) from March to August, covering 60 and 40% respectively. The dominant vegetation types in the area are trees, shrubs, and herbaceous species. The predominant tree species include *Acacia abyssinica*, *Cordia Africana*, *Croton macrostachyus*, *Erythrina brucei*, *Hagenia abyssinica*, and *Juniperus procera*. The livelihood of the local people in the study area depends on mixed farming, but pastoralism predominates over crop production. The typical domestic animals are Camel, Cattle, Goat, and Donkey. The study was carried out in six kebeles selected from 15 rural kebeles of the district based on the availability of traditional healers, agro-climatic zone, recommendation from older people, and local authorities. The six kebeles selected were ‘Sado Werke, ‘Raytu, ‘ ‘Shabo Retebo, ‘ ‘Engoye ilani‘,‘Yedi‘ and ‘Jibri‘ (Figure 1).

Sampling methods and techniques for informants’ selection

A total of 90 respondents (72 male and 18 female) were selected using a random sampling technique from the six study sites. Out of 90 respondents, 12 key informants were systematically selected based on the recommendation of knowledgeable elders, local authorities, and developmental agents. Moreover, they were selected based on particular informants’ explanations during an interview. The ages of the informants were between 18 to 60 years.

Ethnobotanical data collection methods

The standard ethnobotanical data collection methods (Martin 1995; Alexiades 1996; Cotton 1996) were used to document medicinal plant knowledge of the local community. Various data collection tools were used for data collection. Semi structured interviews were undertaken based on the questions prepared in English and translated to the local language (Afaan Oromoo). The data were carefully documented during an interview with participants. The checklist includes medicinal plants, informants’ use to treat human diseases, the plant parts used, the preparation of the remedy, method of administration, and uses other than medicine.

Field observations were performed with the help of key informants on the habit and habitat of medicinal plants. Before the data collection, the consent letter was taken from Madda Walabu University. Before collecting any data, informants’ willingness was asked to participate in the study, and via their oral consent, all data were gathered.

Key informants checked the local names of the voucher specimens of medicinal plants. The pressed and collected specimens were identified by comparing them with already identified specimens in a mini herbarium of Madda Walabu University. Various volumes of the Flora of Ethiopia and Eritrea (Bekele-Tesemma 2007; Edwards et al. 1995; 1997; 2000; Fichtl and Admasu 1994; Hedberg and Edwards 1989, 1995; Hedberg et al. 2004, 2006) were also used in the identification of the collected specimens.

Data analysis

Descriptive statistical tools such as percentage and frequency were used to analyze and summarize data on medicinal plants, their uses, and other related information using MS Excel 2010. Moreover, these ethnobotanical data were analyzed using informant consensus, preference ranking, direct matrix ranking, and Jaccard’s similarity coefficient.

Preference ranking

Preference ranking was conducted for five important medicinal plants to treat evil eyes. The 12 key informants were participated in this exercise to identify the best preferred medicinal plants for the treatment of the evil eye following Martin’s (1995) procedures. The highest value was given to the medicinal plant thought to be the most effective in treating the evil eye (5), while the lowest was given to the least effective plant (1). The value of each species was summed up, and the rank was calculated for each species based on the total ranking.

Direct matrix ranking

Direct matrix ranking was employed following Cotton’s (1996) procedures to compare various importance of a particular plant species based on information gathered from key informants, several multipurpose species were selected out of the total medicinal plants, and use diversities of these plants were listed for eight randomly selected key informants to assign use values to each species. The usage values (5=best, 4=very good, 3=good, 2=less used, 1=least used, and 0= not used) were allocated to each selected vital informant. Then, the values for each species were summarized and ranked. Key informants chose these medicinal plants.

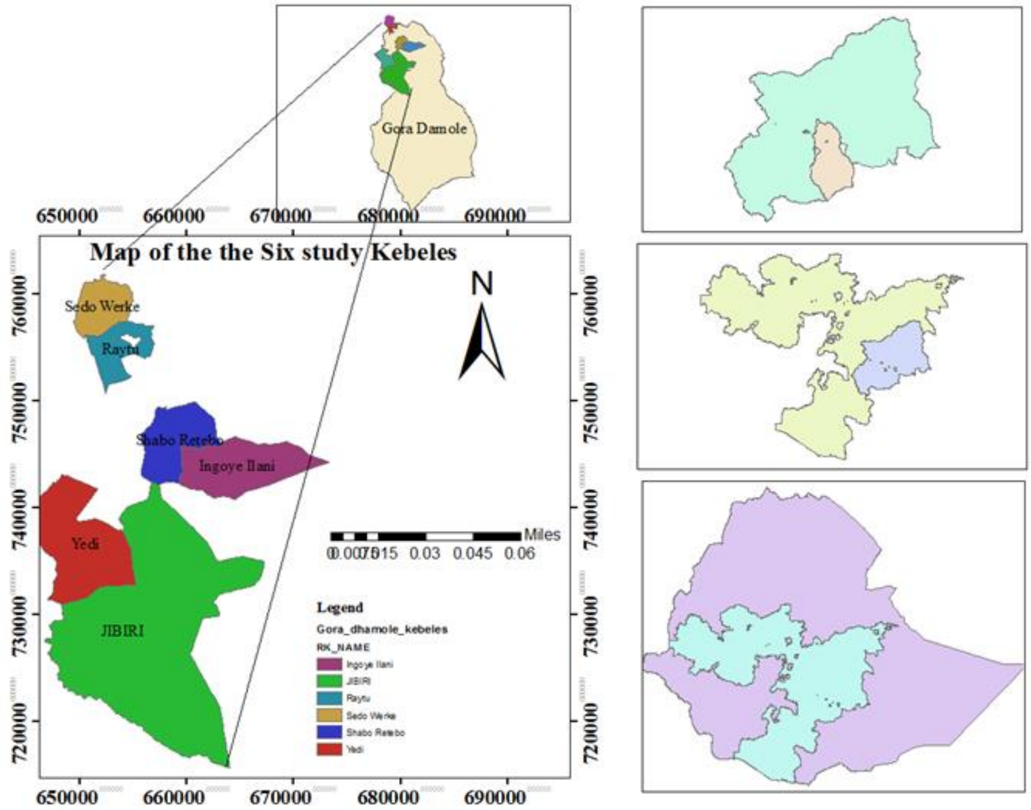

Figure 1. A map showing the study sites (kebeles) along with their District, Zone, Region in the Country, Ethiopia

Jaccard's coefficient of similarity (JCS)

JCS was measured to determine the composition of medicinal plant species and degrees of similarity between different areas. The similarity values were determined between the Gura Damole district and ethnobotanical studies conducted in other regions in different parts of Ethiopia. JCS expressed as follows: JCS = c/(a + b + c), where a is the number of species of sample a site, b the number of species of sample b site, and c is the number of species common to a and b sites (Kent and Coker 1992).

RESULTS AND DISCUSSION

Medicinal plants diversity of Gura Damole district

A total of 30 medicinal plant species belonging to 21 families were recorded in the study area (Table 1). Asteraceae and Solanaceae (3 species each) were the leading plant families, followed by Cucurbitaceae, Euphorbiaceae, Fabaceae, and Lamiaceae (two species each). In contrast, each of the remaining families was represented by one species. Among the reported medicinal plant species, *Olea europaea* subsp. *cuspidata, Solanum incanum,* and *Vernonia amygdalina* were used to treat more than one disease frequently. Among the most commonly used plants were: *Carissa spinarum* (cited by 20 informants), *Silene macrosolen* (12 informants), *Withania somnifera* (11 informants), *Embelia schimperi* (10 informants), and *Bidens pilosa (*8 informants) are some to mention.

The study also identified four growth forms of medicinal plants used to treat human diseases. These growth forms include shrubs (11 medicinal plants), trees (8 medicinal plants), herbs (7 medicinal plants), and 4 lianas (Figure 2).

Medicinal plant parts used

According to the informants' report in the study area, leaves (46.7%) were the dominant part of preparing traditional medicine. The other plant parts used were roots (36.7%), seeds (10%), and stems (6.6%) (Figure 3).

Methods of preparation, conditions, and routes of administration

In the study area, the most common methods of preparation of traditional medicine from plant material were powdering (50%), followed by crushing (22%) **(**Figure 4A). Medicinal plants were administered through different ways, such as oral, dermal, optical, and nasal. The most commonly used way was oral (59%), followed by dermal (20.6%) (Figure 4B). Informants of the study area also reported that medicinal plants mainly harvested were fresh (60%), whereas the remaining (40%) were used in a dry form to treat human diseases.

Table 1. List of medicinal plants for treating human diseases in the study area, Gure Damole district, Ethiopia

Local name	**Scientific name (Voucher number)**	**Family**	**Habit of the plant**	**Disease treated**	**Parts used**	**Method of preparation**	**Method of administration**
Hagamsa	*Carissa spinarum* L. (BA 01)	Apocynaceae	Shrub	Evil spirit and eye	Root	Drying the bark of the root and grinding	Fumigating the smoke and rubbing the medicine on the body of the filled person
Hiddii	*Solanum incanum* L. (BA 11)	Solanaceae	Shrub	stop bleeding from cutting part of human organ	Leaf	Cutting and crushing the leaf	Put the crushed leaf on the bleeding part
				Sudden stomach ache	Root	Chewing the bark of the root	Chewing and swallowing the liquid
Hancotee	*Cucumis ficifolius* A. Rich. (BA 30)	Cucurbitaceae	Herb	Sudden stomach ache	Root	Drying and crushing the root	Mixing with water and drinking
Ulaagaa	*Ehretia cymosa* Thonn. (BA 07)	Boraginaceae	Tree	Fibril illness	Leaf	Cut the leaf	Rubbing the liquid of the leaf on the affected area
Maxxannee	*Bidens pilosa* L. (BA 27)	Asteraceae	Herb	Snake poison	Root, leaf	Chewing the leaf	Put on the bitten part
Hargiisaa	*Aloe pubescens* Reynolds (BA 15)	Aloaceae	Herb	Headache	Stem	Boiling the juice of the plant with milk	Simply drinking the liquid
Hanquu	*Embelia schimperi* Vatke. (BA 18)	Myrsinaceae	Liana	All stomach disease and parasite	Seed	Drying and grinding the seed, make powder and mix with water	Simply drinking
Unso	*Withania somnifera* (L.) Dun. (BA 04)	Solanaceae	Shrub	Evil eye and sprit	Root	Drying, grinding, making powder	Fumigate, washing the body with the prepared powder
Waggartii	*Silene macrosolen* Steud. ex A. Rich. (BA 16)	Caryophyllaceae	Herb	Evil eye and sprit	Root	Drying, grinding, and making powder	Fumigate, rub on the body, wash the body with the medicine
Ejersa	*Olea europaea* subsp. *cuspidata* L. (BA 22)	Oleaceae	Tree	Influenza and fibril illness	Leaf	Cutting the leaf	Simply chewing the leaf
Bakkanniisa	*Croton macrostachyus* Hochst. ex Del. (BA 21)	Euphorbiaceae	Tree	Gonorrhea	Root	Drying, grinding, and making powder and mix with water	Drinking
Roque	*Tamarindus indica* L. (BA 12)	Fabaceae	Tree	Stomach disease	Seed	Mixing the seed with water	Drinking the liquid part of the seed
Harmallaa	*Gomphocarpus integer* A. Rich. (BA 10)	Asclepiadaceae	Herb	Liver disease	Root	Drying, grinding	Boiling and drinking
Waatoo	*Osyris quadripartita* Salzm. ex Decne (BA 17)	Santalaceae	Shrub	Cold	Root, stem	Drying, grinding, making a powder	Fumigate to the filled person
Daboobeessaa	*Rhus vulgaris* Meikle (BA 03)	Anacardiaceae	Tree	Urination problem	Leaf	Cutting fresh leaf	Chewing the fresh leaf
Goraa	*Rubus steudneri* Schweinf. (BA 08)	Rosaceae	Shrub	Stomach disease	Root	Drying, grinding, make a powder, and mix with water	Boiling and drinking
Daamaakasee	*Ocimum gratissimum* L. (BA 29)	Lamiaceae	Shrub	Fibril illness	Leaf	Cut and crush the fresh leaf	Rubbing on the affected body
Tamboo	*Nicotiana tabaccum* L. (BA 19)	Solanaceae	Herb	Evil eye and sprit	Leaf	Drying, grinding, making a powder	Fire and fumigate
Raafuuosolee	*Solanecio angulatus* (Vahl) C. Jeffery (BA 06)	Asteraceae	Herb	Evil eye and sprit	All parts of the plant	Drying, grinding, making a powder	Boil with oil and drinking, rubbing on the body

Qadiidaa	*Rhamnus staddo* A.Rich. (BA 20)	Rhamnaceae	Shrub	Hepatitis	Leaf	Drying, grinding, making a powder	Boil with water and drinking
Birbirsa	*Podocarpus falcatus* L. (BA 25)	Podocarpaceae	Tree	Eye infection	Leaf, bark	Powdering	Mixing with water and drinking
Qobboo	*Ricinus communis* L. (BA 13)	Euphorbiaceae	Shrub	Rabies	Seed and Leaf	Drying, grinding, making a powder	Mixing with water and drinking
Urgeessaa	*Premna schimperi* Engl. (BA 23)	Lamiaceae	Shrub	Teeth infection	Leaf	Cut and crush Fresh leaf	Put the medicine on the infected teeth
Baargamoo	*Eucalyptus globulus* Labill. (BA 24)	Myrtaceae	Tree	Stomach diseases	Leaf	Drying, grinding makes a powder	Mixing with water and drinking
Gaaleexaruu	*Coccinia grandis* (L.) Voigt (BA 09)	Cucurbitaceae	Liana	All disease problems inside the	Root	Drying, grinding, making a powder	Mixing with water and drinking
Ebicha	*Vernonia amygdalina* Del. (BA 14)	Asteraceae	Tree	Headache and eye disease	Leaf	Drying, grinding, making a powder	Fumigate the smoke within the mouth and nose
Ittacha	*Dodonaea angustifolia* (L. Fil.) J.G.West (BA 28)	Sapindaceae	Shrub	Eye disease	Leaf	Cut and crush a fresh leaf	Drop the liquid of the leaf on the infected eye
Handoodee	*Phytolacca dodecandra* L'Her. (BA 26)	Phytolacaceae	Liana	Stomach disease problem	Root	Cutting fresh root	Chewing the root
Laaleessaa	*Rubia cordifolia* L. (BA 05)	Rubiaceae	Liana	Sex problem in males	Root	Drying, grinding, making powder, and mixing with water	Drinking
Ceekataa	*Calpurnia aurea* (Aith.)Benth. (BA 02)	Fabaceae	Shrub	Stomach disease and Amoeba	Leaf	Cut and crush the fresh leaf and squeeze the liquid	Drinking the leaf juice

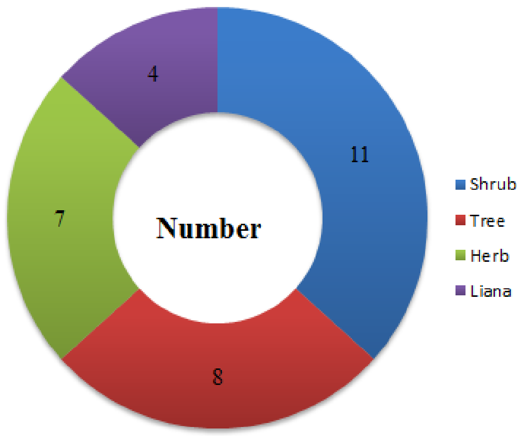

Figure 2. Growth forms of reported medicinal plants

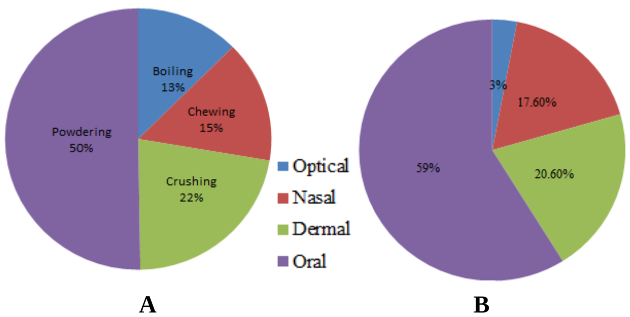

Figure 4. Medicinal plants of Gura Damole district. A: Method of remedy preparation, B: Route of administration.

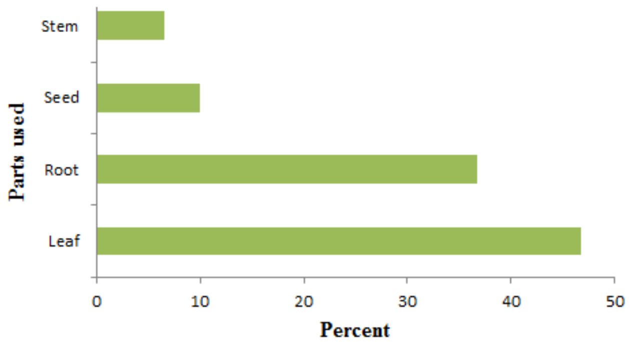

Figure 3. Plant parts used for human ailments treatment in Gura Damole district, Ethiopia

Common human diseases treated by medicinal plants in the study area

About 16 diseases were identified from the study area that medicinal plants locally treated. Moreover, this study determined that a single illness could be cured by more than one medicinal plant, and a single medicinal plant could be utilized to cure more than one disease. For instance, stomachache is a significant disease and can be treated by 8 medicinal plants (Table 2).

Preference ranking

Twelve key informants were asked to compare five medicinal plants based on their knowledge of medicinal plants to treat evil eyes. A score of 5 was assigned to the most effective medicinal plants and one to the least effective medicinal plants. *Carissa sapinarum* was ranked as the preferable medicinal plant for evil eye treatment, followed by *Solanecio angulatus* (Table 3).

Direct matrix ranking

Among the medicinal plants reported by the informants, medicinal plant species have multipurpose use. Key informants first identified six medicinal plants used by the local people for different purposes, including firewood, charcoal production, construction, and food. Application of direct matrix ranking to these species showed that *Carissa spinarum* was the best, followed by *Eucalyptus globulus* and *Croton macrostachyus* (Table 4).

Jaccard's similarity index

The highest similarity between the Gura Damole district and Barbare and Gindeberet district (14%) was noticed in the composition of medicinal plants. In contrast, the degree of similarity was lower with Yalo district (3.7%) (Table 5).

Threats to medicinal plants

Based on the discussion with informants, various factors were reported as primary threats to medicinal plants. Accordingly, the significant factors reported according to their severity were agricultural expansion, charcoal, firewood collection, drought, overgrazing, and recurrent fire.

Table 3. Preference ranking values of nine medicinal plants used to treat evil eye in the study area

Scientific name	Key informants labeled A to L												Total	Rank
	A	B	C	D	E	F	G	H	I	J	K	L		
Carissa spinarum	2	5	1	3	1	1	2	4	2	2	1	0	24	1
Nicotiana tabaccum	3	1	3	2	1	2	0	1	5	3	0	0	21	3
Silene macrosolen	4	2	0	1	2	0	2	2	0	0	2	0	15	4
Solanecio angulatus	5	3	3	4	0	2	1	0	1	1	0	2	22	2
Withania somnifera	2	0	2	2	0	0	2	1	0	1	2	1	13	5

Table 4. Direct matrix ranking of eight multipurpose medicinal plants (Average score of 8 key informants)

Plant species	Respondents (n = 8)					Total	Rank
	A	B	C	D	E		
Carissa spinarum	5	3	2	0	4	14	1
Croton macrostachyus	3	4	3	2	0	12	3
Embelia schimperi	2	0	0	1	5	8	4
Ehretia cymosa	1	1	1	2	1	6	6
Rubus steudneri	2	2	0	0	3	7	5
Eucalyptus globulus	3	4	1	5	0	13	2

Note: A: Medicine, B: Firewood, C: Charcoal, D: Construction, E: Food

Table 2. Human ailments that medicinal plants in Gura Damolthe e district can treat

Ailments treated	No. of medicinal plants
Stomachache	8
Evil spirit	5
Eye infection	4
'Mitch'	3
Headache	2
Hepatitis	2
Bleeding	1
Toothache	1
Amoeba	1
Gonorrhea	1
Influenza	1
Sexual impotence	1
Flu	1
Rabies	1
Urine problem	1
Snake poison	1

Discussions

In the present study, 30 medicinal plant species were identified to treat human diseases, distributed across 21 families. From the 21 plant families, Asteraceae and Solanaceae (10% each) were the major contributing species, followed by Cucurbitaceae, Euphorbiaceae, Fabaceae, and Lamiaceae (6.6% each). Similar to our findings, various studies in Ethiopia (Yohannis et al. 2018; Tesfaye et al. 2020; Teka et al. 2020) and elsewhere globally (Hachlafi et al. 2020) have reported Asteraceae as the most dominant medicinal plant family. In contrast, other studies found that Fabaceae (Kidane et al. 2018; Tefera and Kim 2019), Euphorbiaceae (Jima and Megersa 2018), and Lamiaceae (Kefalew et al. 2015; Tamene et al. 2020) were dominant over others.

This study shows that the most represented life forms of medicinal plants in the study area were shrubs followed by trees. Similar results were also indicated in the earlier ethnobotanical studies conducted in Ethiopia. For instance, the survey conducted by Hunde et al. (2006) in the Boosat subdistrict reported 46% shrubs and 25% herbs, whereas; the study conducted by Yineger and Yewhalaw (2007) in Sekoru district documented 37% of shrubs. The more recent studies conducted by Demie et al. (2018), Jima and Megersa (2018) also reported the dominance of shrubs for the preparation of traditional medicines. However, other findings (Tefera and Kim 2019; Kassa et al. 2020, Pradhan et al. 2020) indicated that herbs were the most frequently used plant categories. The dominance of shrubs and herbs for medicinal plant preparation could be explained in two ways. In one way, the supremacy of shrubs for human diseases treatment could be due to their availability throughout the year and their relative capability of resisting drought that could aid in extensive uses (Maroyi 2011). In another way, the dominance of herbaceous species could be related to the fact that they are easily accessible in nearby areas than trees and shrubs (Lulekal et al., 2013).

The present study results showed that the local people of the Gura Damole district use different parts of medicinal plants to prepare remedies. Leaves were the most widely used part to treat human ailments in the study area. Either roots or leaves are reported as the dominant plant parts used to prepare traditional medicine in Ethiopia and elsewhere in the world. On the one hand, the leaves were a widely used medicinal plant part used to treat human ailments in Ethiopia (Tesfaye et al. 2020; Kassa et al. 2020) and other countries (Wet et al. 2010; Hachlafi et al. 2020; Pradhan et al. 2020; Wanjohi et al. 2020). On the other hand, (Mesfin et al. (2009) and Kefalew et al. (2015) reported that the roots were widely used plant parts. Various authors stressed that using roots for traditional medicine preparation could have a detrimental impact on plant species. A study by Kassa et al. (2020) revealed that *Echinops kebericho*, whose root is highly marketable in local markets of the Sheka zone, is affected.

Most of the medicines (60%) were prepared in the study area from fresh plant materials. Similar findings were also recorded in different studies from other parts of Ethiopia (Jima and Megersa 2018; Tefera and Kim 2019; Kassa et al. 2020). The preference for fresh plant parts is related to the efficacy of medicinal plants in treating diseases compared with dried parts (Kassa et al. 2020). The utilization of fresh plants or plant parts could have a detrimental impact on plants through systematic collection compared to dried pieces. Once the plant part is collected and dried, it can be used for later use; however, local people made minimal efforts in storing dried plant material for later use, as reported in the results of Kassa et al. (2020).

About 59% of the medicines in the area were administered orally. In similar studies, other researchers reported oral administration of medicine as the leading route of application (Demie et al. 2018; Kassa et al. 2020). This finding could indicate internal ailments are common in the study area. However, researchers recommend that care be given while taking the remedy, as overdosage could cause severe internal problems (Chekole 2017; Kassa et al. 2020). Dermal application of traditional medicine as the dominant way was also reported by Giday et al. (2009) and Tesfaye et al. (2020).

Jaccard's similarity index indicated some similarity in the composition of medicinal plants between the study area and the Gindeberet district (Zerabruk and Yirga 2012) and Barbare district Jima and Megersa (2018). In contrast, less similarity was found between Yalo district (Teklehaymanot 2017) and Jigjiga town (Alebie and Mohamed 2016). The similarity and dissimilarity between the present study and other districts could be due to cultural and agroclimatic conditions, as Tefera and Kim (2019) stated.

According to the responses from informants, the leading causes of the loss of medicinal plants in the study area were agricultural expansion, charcoal, firewood collection, drought, overgrazing, and recurrent fire. Similar to the present finding, other studies on threats to medicinal plants in Hawassa Zuria district, Tefera and Kim (2019), indicated agricultural expansion is the primary threat to medicinal plants.

Comparison with previous ethnobotanical studies conducted in Ethiopia

Medicinal plant species used most frequently to treat human diseases in this study were searched in Ethiopia's published similar research works (Amsalu et al. 2018; Tefera and Kim 2019, Tamene et al. 2020). From this review, medicinal plant species used by communities of the Gura Damole district are likely to be found in other parts of Ethiopia. Medicinal plants such as *Carissa spinarum*, *Cucumis ficifolius*, *Withania somnifera*, *Embelia schimperi*, *Ehretia cymose*, and *Ocimum gratissimum* had similar uses with other studies, and *Croton macrostachyus*, *Bidens pilosa*, *Solanum incanum*, and *Gomphocarpus integer* had different functions (Table 6).

The present study documented 30 medicinal plants and their uses for human ailments treatment. Medicinal plants could treat Sixteen human ailments of the Gura Damole district, where a single medicinal plant was reported to treat more than one ailment. On the other hand, a single disease could be treated by more than one medicinal plant, as evidenced in the study. Shrubs were found to be the dominant growth form of medicinal plants used to prepare traditional remedies and followed by Trees. Leaves were the most frequently used plant parts of preparing traditional remedies. The study also indicated that local communities preferred medicinal plants over others, probably due to their efficacy. In this regard, *Carissa spinarum* is considered the best selected medicinal plant to treat evil eyes. The therapeutic activity of some medicinal plants reported in the study area also had a similar function with other study areas. Hence, future phytochemical and pharmaceutical investigations could consider such plants in fighting against human ailments, including emerging and pandemic diseases.

Table 5. Jaccard Index of similarity of the present study area across different districts inside Ethiopia

Study areas (districts)	Species no. (a or b)	Common species (c)	Jaccard index	References
Gura Damole district	30	-	-	*This study*
Barbare district	70	14	14	Jima and Megersa (2018)
Sekoru district	27	5	8.7	Yineger and Yewhalaw (2007)
Gindeberet district	26	8	14.2	Zerabruk and Yirga (2012)
Dirre Sheik Hussen	78	11	10.2	Demie et al. (2018)
Mana Angetu district	208	22	9.2	Lulekal et al. (2008)
Dhera town	73	12	11.6	Wondimu et al. (2007)
Gubalafto district	135	17	10.3	Chekole (2017)
Gozamin district	91	14	11.5	Amsalu et al. (2018)
Dega Damot	60	9	10	Wubetu et al. (2017)
Dek island	60	9	10	Teklehaymanot (2009)
Yalo district	103	5	3.7	Teklehaymanot (2017)
Bench community	35	3	4.6	Giday et al. (2009)
Hawassa Zuria district	97	14	11	Tefera and Kim (2019)
Meinit ethnic	51	8	9.8	Giday et al. (2009)
Amaro district	56	8	9.3	Mesfin et al. (2014)
Boricha district	38	5	7.3	Tamene et al. (2020)
Asgede Tsimbila district	65	9	9.5	Zenebe et al. (2012)
Alamata district	25	3	5.4	Yirga (2010)
Jigjiga town	46	3	4	Alebie and Mohamed (2016)
Mandura district	60	5	5.5	Mengesha (2016)
Berta ethnic	40	4	5.7	Flatie et al. (2009)

Table 6. Diseases treated by medicinal plants in this study and other study areas

Rank	Medicinal plants	Diseases treated	References
1	*Carissa spinarum* L.	Evil spirit	*This study*
		Wound, evil spirit	Tefera and Kim 2019
2	*Croton macrostachyus* Hochst. ex Del.	Gonorrhea	*This study*
		Hook worm, tinea cor.	Demie et al. 2018
		Malaria	Chekole 2017
		Stomachache, malaria	Amsalu et al. 2018
3	*Withania somnifera* (L.) Dun.	Evil spirit	*This study*
		Typhoid, evil spirit	Teklehaymanot 2017
		Fibril illness, evil spirit	Wondimu et al. 2007
		Fibril illness, an evil spirit	Mesfin et al. 2014
4	*Embelia schimperi* Vatke.	Internal parasites	Study area
		Tape worm	Demie et al. 2018
5	*Bidens pilosa* L.	Snake poison	*This study*
		Evil spirit	Chekole 2017
6	*Solanum incanum* L.	Bleeding	*This study*
		Hemorrhage, toothache	Alebie and Mehamed 2016
		Stomachache, swelling	Zenebe et al. 2012
		Headache, impotence	Lulekal et al. 2008
	Cucumis ficifolius A. Rich.	Stomachache	*This study*
		Rabies, stomachache	Teklehaymanot 2009
7	*Gomphocarpus integer* A. Rich.	Liver diseases	*This study*
		Evil spirit	Wondimu et al. 2007
		Gastritis, gonorrhea	Lulekal et al. 2008
8	*Ehretia cymosa* Thonn.	Fibril illness	*This study*
			Tamene et al. 2020
		Stomachache	Demie et al. 2018
		Cancer	Tefera and Kim 2019
9	*Ocimum gratissimum* L.	Fibril illness	*This study*
			Demie et al. 2018
			Lulekal et al. 2008
		Malaria, cancer	Tefera and Kim 2019
		Eye diseases	Lulekal et al. 2008

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Local knowledge of plant-based nutrition sources from forgotten foods in Datengan Village, East Java, Indonesia

WHISNU FEBRY AFRIANTO[1,♥], FADILA TAMNGE[2,♥♥], TAUFIQ HIDAYATULLAH[3], LAELI NUR HASANAH[4]

[1]Ecosystem and Biodiversity (Ecosbio). Jl. Merapi 02/01, Datengan, Grogol, Kediri 64151, East Java, Indonesia, ♥email: whisnu.afrianto@apps.ipb.ac.id
[2]Departement of Forestry, Universitas Khairun. Jl. Pertamina Kampus II Unkhair, Gambesi, Ternate 97719, North Maluku, Indonesia
[3] Program of Agricultural Development, Politeknik Pembangunan Pertanian Medan. Jl. Binjai Km. 10, Paya Geli, Deli Serdang 20351, North Sumatra, Indonesia
[4]Departement of Nutrition, Faculty of Science and Technology, Universitas PGRI Yogyakarta. Jl. IKIP PGRI I Sonosewu No. 117, Bantul 55184, Yogyakarta, Indonesia

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Abstract. *Afrianto WF, Tamnge F, Hidayatullah T, Hasanah LN. 2021. Local knowledge of plant-based nutrition sources from forgotten foods in Datengan Village, East Java, Indonesia. Asian J Ethnobiol 4: 53-64.* Plant-based food has benefits for health and the environment. Finding adequate plant-based nutrition sources can be found by exploring local knowledge. Here, forgotten foods mean two definitions that (i) those foods were consumed by the community before, but over time it is forgotten in the daily diet, and (ii) unusually consumed by the community outside, but it still is or over-consumed by the community. This study aimed to identify the plant-based nutrition sources in Datengan Village. The study was conducted in the Datengan Village, Grogol Sub-district, Kediri District, East Java Province, Indonesia. Ethnobotany approach through qualitative research (i.e., observation, semi-structured interview, and participant observation) were used to explore the plant-based nutrient sources from forgotten foods in Datengan Village. The results showed forgotten foods in Datengan Village, i.e., fermented foods, mushrooms, by-products, and plant rich-nutrition. There were 26 plant-rich-nutrition, two mushrooms, two fermented foods, and six by-product foods. This investigation is still a preliminary study. 14 handling, processing, and serving methods were used based on the interview. This plant-based nutrition source diversity can be an alternative to fulfill nutrient requirements for the community of Datengan Village and the community of outside areas.

Keywords: Forgotten foods, local knowledge, nutrition sources, plant-based foods

INTRODUCTION

That fast-growing population has several challenges. For example, Indonesia has serious hunger issues and ranks 70 out of 119 countries (von Grebmer et al. 2019). World Food Program (WFP) data revealed that 19.4 million of Indonesia's population suffer from malnutrition (World Food Programmes 2017). Besides, Indonesia's stunting cases are equal to 63% of children’s stunting issues in Southeast Asia (FAO 2018).

In the early 1970s, Indonesia applied the green revolution to increase rice production. The program is known as The Five-Farming Efforts *(Panca Usaha Tani)*, i.e., the high-yielding rice varieties, chemical fertilizer and pesticides, irrigation, and intensive rice planting method (Partasasmita et al. 2019; Hidayat et al. 2020). The green revolution's impact is shifting the daily consumption of communities that focus only on rice. By exploring, forgotten foods can be alternative solutions to several challenges from five essential aspects: environmental, agronomic, economic, social, and political elements (Cheng 2018). Thus, food diversity, primarily plant-based foods, can improve the security of food production and as future functional foods (Mayes et al. 2012; Cooper 2015; Baldermann et al. 2016; Massawe et al. 2016; Cheng 2018).

A plant-based diet benefits health and the environment (Lynch et al., 2018). For health, several studies have reported that a plant-based diet can reduce the risk of chronic diseases such as cancer (Catsburg et al. 2015; Orlich et al. 2015; Tantamango-Bartley et al. 2016), mortality and morbidity caused by ischemic heart disease (Szeto et al. 2004; Kwok et al. 2014; Dinu et al. 2017), Diabetes type 2 (Tonstad et al. 2013; Satija et al. 2016), Metabolic syndrome (MetS) (Burkert et al. 2014; Turner-McGrievy et al. 2016). Also, the impact for the human body makes lower glucose (Dinu et al. 2017), body mass index (BMI) (Burkert et al. 2014), diastolic and systolic blood pressure (Pettersen et al. 2012; Yokoyama et al. 2014), triglycerides (De Biase et al. 2007), and lipoprotein cholesterol (Ferdowsian and Barnard 2009; Wang et al. 2015). For the environment, plant protein can reduce water, energy, and land, as well as reduce the GHGEs impact when it is compared with animal protein (Carlsson-Kanyama et al. 2003; Leitzmann 2003; Pimentel and Pimentel 2003; Reijnders and Soret 2003; Baroni et al. 2007; Marlow et al. 2009; Masset et al. 2014: Sabate et al. 2014; Soret et al. 2014; Springmann et al. 2016).

In this study, forgotten foods here mean two definitions: (i) those foods are consumed by the community before, but it is overlooked in the community's daily diet over time; (ii) Forgotten foods are unusually consumed by the community outside, but it is still or over-consumed by the community (Palupi et al. 2020). This study aims to identify the plant-based nutrition sources in Datengan Village, Kediri, Indonesia. The nutrition source diversity can be an alternative to fulfill nutrition requirements for the community of Datengan Village and outside of the areas.

MATERIALS AND METHODS

Study area

The study was conducted in the Datengan Village, Kediri District, East Java Province, Indonesia. Datengan Village has three hamlets, i.e., Sumbersari, Datengan, and Semen. The village is located in latitude -7.73921 S7º 44'21.5826" and longitude 111.99176 E 111º59'30.30918". The majority of the community's livelihoods are farmers. To reach the city of Kediri, it needs approximately 30 minutes by car with a distance of about 15 km. Topographically, Datengan Village is low-land and has an altitude between 66 to 80 m asl.

Data collection

Ethnobotanical data were documented through the qualitative approach (i.e., observation, semi-structured interview, and participant observation). It was used to explore the nutrition sources from forgotten foods in Datengan Village. An in-depth interview with local experts was conducted using a semi-structured interview. Informants were purposively selected using snowball sampling, including village staff, family welfare education (PKK) members, elders, and households. The in-depth discussion followed prepared interview guidance based on a list of questions related to the topic of study. The observation was carried out to identify community-based socio-environmental aspects by foraging in home gardens, mixed gardens, and farms.

Data analysis

The data was analyzed by cross-checking, synthesizing, and summarizing based on observation, semi-structured interviews, secondary data, and participant observation. Also, the literature review was applied to support the study. The data was divided into four categories, i.e., (i) plant-rich nutrition, (ii) by-product, (iii) fermented food, and (iv) mushroom. The description of each category is provided in Table 1.

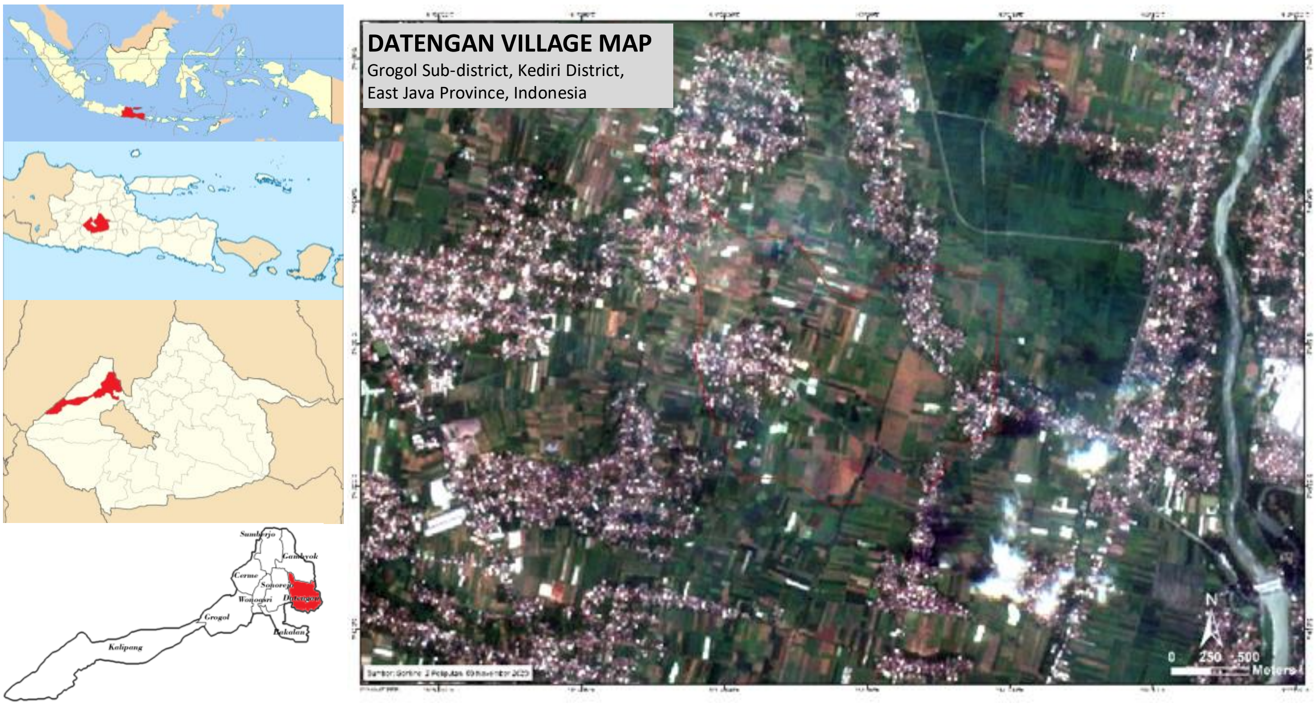


Figure 1. Map of Datengan Village, Grogol Sub-district, Kediri District, East Java Province, Indonesia

Table 1. Definition of each plant-based protein category

Category	Definition
Plant rich-nutrition	Raw materials (leaf, flower, fruit, tuber, seed, and stem) from plants
By product	A secondary product that is processed using the traditional method
Fermented food	Food is processed by using microorganisms
Mushroom	Mushroom taxonomically is not a plant, but mushroom is usually used as an ingredient in plant-based dead. Besides, following the Indonesia Ministry of Health, a mushroom is categorized as a vegetable (*sayuran*) in Indonesian Food Composition Data (Indonesia Ministry of Health 2018)

RESULTS AND DISCUSSION

Usually, traditional foods need plants as essential ingredients. The different regions also have other sources, processes, and components. This study documented 26 plant-rich proteins, two mushrooms, four fermented foods, and six by-product foods. All results found in this study are provided in Table 2-5. The plant-based nutrition sources in Datengan Village consisted of 18 families, and it was dominated by the Fabaceae (8 species) (Figure 2a). The plant part was dominated by the leaf (26%) (Figure 2b). Datengan's community collected the foods from their home gardens (*pekarangan*) and fields. In this village, the community has quite a space to grow several shrubs, trees, herbs, and ornamental plants in their home gardens. Food plants have a significant role in Datengan's Community. The local people consume plant-based foods more often than animal-based foods, and based on economic consideration, plant-based foods are cheaper than animal-based foods.

Leaf

In this study, the community consumed the leaves of nine plants. Commonly, the people of Datengan use the plants like shade, hedgerows, and crops. Even though several plants were wild and weed, such as *Marsilea crenata*, *Sauropus androgynus*, and *Portulaca oleracea*. The dried leaf extract of *M. crenata* showed the significant inhibitory activity of the HMG-CoA reductase enzyme and contained flavonoids, phenolic phytochemicals, and steroids (Hardoko et al., 2019). The ethyl acetate fraction of *Carica papaya* leaf has flavonoids, phenolics, alkaloids, and terpenoids compounds. Moreover, the ethanolic extract of *C. papaya* leaf revealed no potential cytotoxicity on T47D cells, causing high IC50 values (Yuliani and Syahdeni 2020), and accelerated the healing of oral ulcers on the buccal mucosa in the Wistar rat experiment (Femilian et al. 2019). *C. papaya* leaf also is utilized to increase platelets in a patient with dengue hemorrhagic fever and *Aedes aegypti* larvacide (Swastika 2015; Adnyani and Sudarmaja 2016; Ramayanti and Febriani 2016; Agustina 2019; Rahayu and Satmoko 2019: Mustika et al. 2020; Sari and Khaira 2020; Sudarwati et al. 2020). *Moringa oleifera* is also known as a superfood since the protein quality of *M. oleifera* leaf is higher than milk and eggs (Fahey 2005). The extract of *M. oleifera* leaf is used to cure malnutrition and augment breast milk in lactating mothers (Gopalakrishnan et al., 2016). *Sauropus androgynus* also is known to have superior nutrition and vitamin content (Bunawan et al., 2015). It has approximately 7.4 g of protein per 100g of fresh leaves (Padmavathi and Rao 1990). The antioxidant activity of ethanol extract of *Ipomoea batatas* is higher than α-tocopherol (Sulastri et al., 2013). According to Terangpi et al. (2013), the leaf of *Gnetum gnemon* contains high fiber content that has many benefits for health. *Cosmos caudatus* leaf extract shows impacting SGPT levels in the blood of Wistar rats-induced paracetamol (Maulida et al. 2020). *C. caudatus* leaf extract at a 600 μg/ml concentration increased the proliferation of human gingival fibroblasts culture and is non-toxic activity (Shabrina et al. 2018). Susanto et al. (2020) stated that *C. caudatus* at a maximum dose of 7.5 kGy could be preserved using gamma irradiation to avoid changing its anti-cancer properties. The young leaf of *C. caudatus* can be used as herbal tea to increase maturity because it has antioxidant activity (Dian-Nashiela et al., 2015). *C. caudatus* has the potential of antidiabetic activity, anti-hypertensive, bone-protective, anti-inflammatory, antimicrobial, and anti-fungal activity (Javadi et al. 2014; Cheng et al. 2015). Based on analysis from Palupi et al. (2020) showed that *C. caudatus* has a higher protein (19.45%) than *M. olifera* (18.45%) and *Pluchea. indica* (17.36%). *P. indica* leaf extract can be used as therapy in counteracting free radicals and improves histopathology in the liver, jejunum, and kidney (Aulanni'am et al., 2019). The leaf extract of *P. indica* has anti antibacterial activities such as *Enterococcus faecalis* and *Fusobacterium nucleatum* (Pargaputri et al. 2016; Pargaputri et al. 2017), *Propionibacterium acnes* (Hafsari et al. 2015), *Bacillus cereus*, *Pseudomonas fluorescent*, and *Salmonella typhimurium*, as well as also as an antioxidant (Srimoon and Ngiewthaisong 2015; Widyawati et al. 2018). *P. oleracea* has been reported to contain several pharmacological properties such as neuroprotective, antidiabetic, antimicrobial, antiulcerogenic, antioxidant, anticancer activities, and anti-inflammatory (Okafor and Ezejindu 2014; Uddin et al. 2014; Zhou et al. 2015). The crude extracts of *M. crenata* leaf have 6 bioactive compounds, such as steroid, alkaloid, carbohydrate, flavonoid, and decreasing free amino acid and sugar (Nurjanah et al., 2012).

Seed

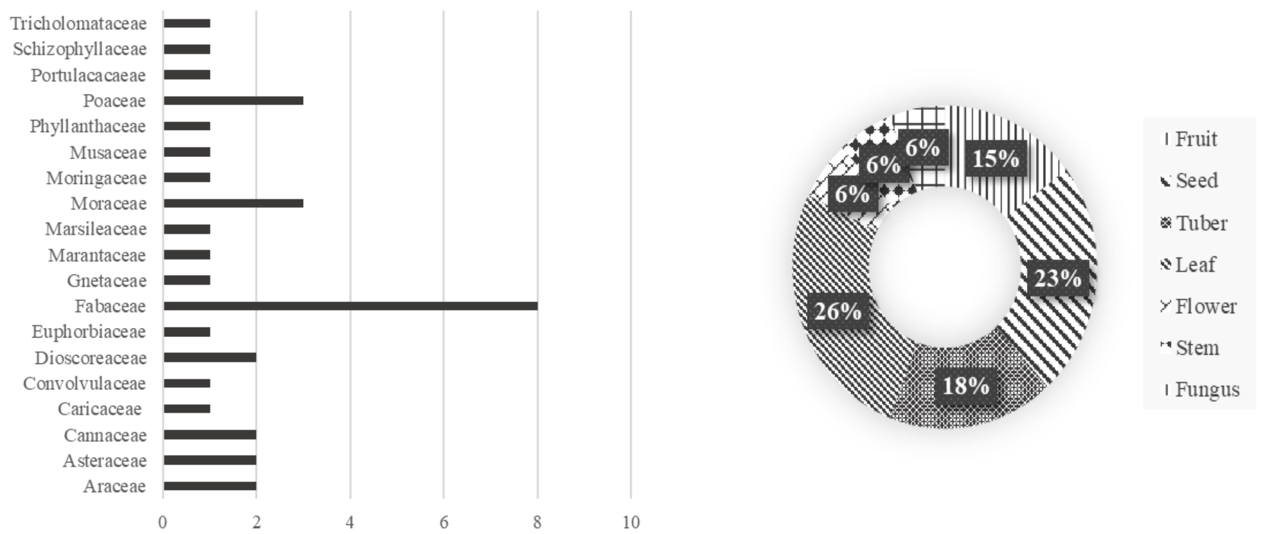
The seed plants are commonly from legumes because most legumes have a protein that contains about 17-30% and are considered a high-quality source (Reddy et al. 1984). There were six plants consumed based on their seed part. The protein of *Canavalia gladiata* contains a high lysine level (6.49%) (Bressani et al., 1987; Rajaram and Janardhanan 1992). Even though *C. gladiata* and *C. ensiformis* have high proteins, but they are still underutilized plants (Rajaram and Janardhanan 1992; Ekanayake et al. 2000). Black and red of *C. gladiata* are excellent antioxidant phenolic sources (Gan et al. 2016). In a rat experiment, using seed extract of *C. gladiata* with doses of 100 and 200 mg/kg can decrease AZP-induced hepatotoxicity (Kumar and Reddy 2014). *C. ensiformis* has been tested containing the neutral lipids of 2.21% of whole seeds, as well as the fatty acid, i.e., palmitic (15%), oleic (54%), linolenic (8%), and linoleic (7%) (Gaydou et al. 1992). *Vigna unguiculata* contains %moisture content, crude fat, fiber, protein, carbohydrate of 7.40±0.70, 1.77±0.03, 0.72±0.01, 14.95±0.14, 70.05±0.14, respectively (Musah et al. 2020). The mature seed of *Leucaena leucocephala* has been reported to contain a high of protein (30.81%) rather than dry and fresh leaves (Ekpenyong 1986; Sethi and Kulkarni 1995). Phytochemical investigation of various extracts of *Sesbania* *grandiflora* showed steroid, flavonoid, saponin, phenolic, and tannins compounds (Semwal et al., 2018). *G. gnemon* has two protein fractions and antioxidant activities against free radicals (i.e., ABTS, DPPH, and superoxide anion) (Siswoyo et al., 2011). The doses of 600 mg/kg BW of ethanol extract of *G. gnemon s*eed showed a significant antidiarrheal effect (Kardela et al., 2018).

Tuber

There were five plants consumed as a food alternative based on their tuber. Local accessions of *Dioscorea alata* from East Java showed that it has macronutrients such as protein (1.29-3.00%), carbohydrate (17.10-29.37%), moisture (65.47-82.46%), fiber (6.70-11.62%), fat (0.00-0.29%), and ash (0.85-1.44%) (Fauziah et al. 2020). The ethanolic extract of *Maranta arundinacea* arrowroot in a rat experiment revealed that it could decrease the concentration of MDA, SGPT, and SGOT (Ramadhani et al., 2017). According to Wijaya et al. (2014), *C. edulis* has scopoletin content (coumarin compound). *Xanthosoma sagittifolium* has an appreciable source of energy, protein, and vitamins that can be used to solve malnutrition challenges (Boakye et al. 2018; Wada et al. 2019). *Dioscorea hispida* is underutilized due to cyanide (HCN) compounds poisoning. To reduce the HCN in *D. hispida*, it can use ash during soaking with boiling (Pramitha and Wulan 2017), as well as repeat washing up to three times (Saleha et al. 2018). *D. hispida* with 630 mg/BW and 1260 mg/BW have been reported reducing glucose concentration with insulin effect in the rat experiment (Sunarsih et al. 2007). Nowadays, these tuber plants are rarely consumed by Datengan's Community. These tuber plants were the source of energy, protein, and carbohydrate as a staple food. They usually consume these tuber plants by steaming, making chips, and boiling.

Fruit

Based on the interview, four plants were consumed by Datengan's Community. The use of *Psophocarpus tetragonolobus* is the fruit or just seed. In the village of Datengan, the community consumed pods of *P. tetragonolobus* as *jangan asem* and *urap* (Table 2). A rat experiment extract using *P. tetragonolobus* with a 500 mg/kg BW dose showed a potential anti-osteoporosis activity (Nurmala et al., 2018). *P. tetragonolobus* is a legume that has beneficial nutritional characteristics. According to Kantha and Erdman (1984), protein contents in the ripe seed of *P. tetragonolobus* are around 29.3-39.0%. As an underutilized legume with rich protein content, the species will be a potential source to alleviate the protein malnutrition problem (Adegboyega et al., 2019). The cooking method with prolonged soaking time will provide the flavor, develop the weight of cooked beans, tenderness, and increase the protein of *P. tetragonolobus* (Ekpenyong and Borchers 1980). Fruit of *Artocarpus heterophyllus*, *A. camansi*, and *A. altilis* have a similar shape. *A. heterophyllus* is consumed both young and ripe. For young fruit, the people of Datengan Village cook for *jangan lodeh* and *bobor*. Immature fruits of *A. heterophyllu*s have protein contains higher than ripe fruits (Ranasinghe et al., 2019). The fruit extract of *A. camansi* has an optimum percentage antioxidant activity to inhibit free radicals at 50.65% (Arif et al., 2018). Moreover, a rat experiment using the extract of *A. altilis* showed that it has a significant anti-atherogenic effect and provides favorable lipid parameters to improve the antioxidant system of hypercholesterolemic (Adaramoye and Akanni 2014).



A B

Figure 2. A. Plant family of protein sources in Datengan Village, East Java, Indonesia. B**.** Part used of protein sources in Datengan Village, East Java, Indonesia

Figure 3. Several forgotten foods in Datengan Village, Indonesia A. *Sesbania grandiflora (*flowers), B. *Musa paradisiaca* (flowers), C. *Moringa oleifera* (leaves), D. *Sauropus androgynous* (leaves), E. *Colocasia esculenta* (stems), F. *Vigna unguiculata* (seeds), G. *Artocarpus camansi* (fruits), H. *Carica papaya* (leaves), I. *Xanthosoma sagitifolium* (tubers), J. *tempe gembus* (a by-product from *Glycine max*), K. Cassava *tape* (fermented food from *Manihot esculenta*), L. *Gaplek* (a product from *Manihot esculenta*)

Stem

Two plants were consumed with their stem by Datengan's Community. The young stem of taro (*Colocasia esculenta*) and young shoot of bamboo (*Bambusa* sp.) were sold in 15 traditional markets in Kediri District (Yurlisa et al. 2017). The young node of bamboo's physical characteristic is soft and crunchy (Ainezzahira et al., 2017). Nutrients of the young bamboo shoot are carbohydrates, proteins, vitamins, minerals, and bioactive compounds (Nirmala et al. 2014; Felisbertoa et al. 2017). The young shoot of bamboo also has been reported to reduce blood pressure and blood cholesterol levels (Makatita 2020). The bamboo young shoot's different processing techniques (i.e., fermentation, boiyoung bamboozling) impact the nutrient contents (Satya et al., 2010). The study about the young stem of *C. esculenta* is still limited rather than other parts of *C. esculenta*. Extraction of the young branch of *C. esculenta* through the maceration method at 96% ethanol shows it has the highest antioxidant activity with an IC50 value (74.75 ppm), a total flavonoid of 97.38 mg QE/g extract, and complete phenolic content of 78.98 mg GAE/g extract (Pramiastuti et al. 2019). Both of them are cooked as *jangan bobor* and *lodeh*.

Flower

We also found that Datengan's Community consumed edible flowers such as *Musa paradisiaca* and *Sesbania grandiflora*. Genus Sesbania, around 60 species, is used as a medicinal and therapeutic plant commonly found in Asia, Australia, and Africa (Mohiuddin 2019). Not only *S. Grandiflora* flower but also all parts can be used for medicinal purposes (Kashyap and Mishra 2012; Alahakoon and Gagegoda et al. 2019). With ethanol extracts, S. Grandiflora flower and leaf showed anticancer activity at 100 and 200 mg/kg (Sreelatha et al., 2011). Also, in experiments in mice, methanolic extract (200 and 400 mg/kg) of *S. Grandiflora* flower can increase the provider of circulating antibodies (Arunabha and Satish 2014). The comparison of flavonoid content between white and red flowers are 12.58-21.35 mg.100 g-1 and 17.32-30.05 mg.100 g-1 (Setiawan 2018), and alkaloid content 17.8% and 18.93%, respectively (Wiranawati et al. 2017). On the other hand, the blossom of banana (*M. paradisiaca*) or jantung pisang in the local language has been reported to contain antioxidant activity (Krishnan and Sinija 2016; Ferdinan and Prasetya 2018), and flavonoid (Walida et al. 2016). Consuming banana blossoms also can raise maternal breast milk output (Rilyani and Wulandasari et al., 2019). Both of them are cooked as *jangan bobor*.

Mushroom

We found two mushroom species consumed by Datengan's Community, i.e., *S. commune* and *C. nebularis*. Datengan's Community does not usually consume mushrooms in their daily consumption because they are rarely found (bloom in transitional season). Besides, they also need special treatment in cooking because people are afraid that the mushrooms are poisonous. Another region of East Java is Wonojati Village, Pasuruan District; they also have been reported to consume these mushrooms (Anwar el at. 2014). Usually, people consume these mushrooms as *bothok,* steamed with spices and grated coconut, and wrapped with banana leaves.

Fermented foods

This study recorded two fermented foods as *tape ketan* (black glutinous rice) and *singkong* (cassava). The black glutinous rice (*ketan*) makes a white and black tape. The starch in cassava and glutinous rice is essential for fermentation products. Fermentation is conducted by using *Saccharomyces cerevisiae* yeast that converts starch to alcohol. *Tape* is served in special moments such as Eid Al Fitr, weddings, meetings, recitations, or other special events. The cooking method of steam or boil is not relatively different from making *tape based* on color, pH, organoleptic properties, ethanol content, and sugar reduction (Marniza et al. 2020).

Black glutinous rice (*ketan hitam*) contains a high anthocyanin compound called pelargonidin 3-glucoside (Adrianta 2016). To serve *tape ketan*, it is steamed or boiled for around 30-40 minutes, then wrapped with banana leaves, and put in a closed or darkroom can produce the best quality *tape keta*n (Kanino 2019). The fermented process does not affect the anthocyanin content of black glutinous rice (Suhartatik et al., 2013). The white glutinous rice (ketan putih) protein is 6.81% (Suriani 2015). The yeast has an essential impact on producing alcohol in cassava and *tape ketan* (Berlian 2016). According to Fathnur (2019), the yeast doses of 1% resulted in the highest alcohol in cassava and the white glutinous rice. On the other hand, cassava is not correlated with ethanol levels (Dirayati et al., 2017).

The alcohol concentration in the *tape* is not affected by fermentation (Sari and Fajar 2019). The alcohol-contained *tape* needs consideration in the halal aspect because MUI Fatwa Number 4 in 2003 stated that containing ethanol (C_2H_5OH) >1% is categorized as *haram* foods (forbidden foods in Islam).

By-products

Datengan's Community also consume *tempe busuk* and *tempe gembus*. *Tempe busuk* or *tempe* overripe or *tempe* over fermented is cooked to make *sambal tumpang*. In Kediri, *sambal tumpeng* is eaten with *sambal pecel* and *rempeyek*. *Tempe busuk* dried at 60ºC is preferred by the consumers because it is not too stingy, has a good texture, is dry, and has a brown color (Andriani et al. 2013). *Tempe busuk* even has been reported to contain a higher protein of 33.22% than *tempe gembus* of 29.42% (Palupi et al. 2020). *Tempe gembus* is a fermented byproduct of tofu (soybeans). Adding 15% *bekatul* in *tempe gembus* provides a smoother texture, 57.24% protein dissolved, and 57.65% protein digested (Murdiati et al. 2000). *Bekatul* has protein as energy of 8.57% (Palupi et al. 2020). *Tempe gembus* variation has been reported to reduce the Hcy and MDA levels (Kurniasari et al., 2017). *Tempe gembus* with bromelain enzyme for 28 days also can decrease fibrinogen and the serum levels of hsCRP in rats (Dewi et al. 2018).

Gatot and *tiwul* are a local food from Gunung Kidul. In Gunung Kidul, dry land makes rice are not suitable to grow. Thus, people consume cassava (the main ingredient) as their food. These foods are consumed with grated coconut and wrapped with banana leaves. Datengan's Community has also consumed these foods, but now people rarely consume *Gatot* and *tiwul*. They currently consume these foods only as a traditional snack (jajanan pasar), so the portion is only tiny and not a staple food anymore. These foods are an alternative to functional foods. For example, *tiwul* has been reported to have a low glycemic index (34.21-37.50) (Hidayat et al., 2016).

In Datengan Village, *nasi jagung* (corn rice) is consumed with *urap*, *sambel tumpang,* and *rempeyek*, or it is also mixed with rice as a staple food. The corn with 12 hours' storage has the highest glucose level of 32.250 ppm (Novianti et al., 2017). According to Novianingtyas et al. (2020), there is no correlation between the consumption habits of nasi jagung and blood glucose in women 31-45 years old. *Nasi jagung* needs more processing corn that it makes people prefer to consume rice than *nasi jagung*. Even though, Maligan et al. (2019) stated that consumers prefer to consume *nasi jagung* rather than rice.

In conclusion, there were 27 plant-rich protein sources, two mushrooms, two fermented foods, and six by-product foods. This investigation is still a preliminary study. Reintroducing nutrition sources from forgotten food needs integration between ethnobotany, bioprospecting, conservation efforts, and market access (Afrianto et al. 2020). The knowledge of cultivating and the creativity of handling, processing, and cooking are needed to empower the community to utilize them. Collaboration with related stakeholders is also required, especially training, funding, and building a sustainable chain food system.

Table 2. Fresh produce of plant-based nutrition sources in Datengan Village, East Java, Indonesia

Local name	Latin name	Family	Parts of plant	Processed product	How to cook and serve
Lamtoro	*Leucaena leucocephala*	Fabaceae	Seed	*Bothok*	*Bothok*: Steamed with spices and grated coconut, wrapped with banana leaves
Kacang tholo	*Vigna unguiculata*	Fabaceae	Seed	*Lodeh*	*Lodeh*: Boiled with spicy, long bean, and coconut milk
Kecipir	*Psophocarpus tetragonolobus*	Fabaceae	Fruit (pod)	*Urap* and *sautéed*	*Urap*: Mixed with other leaves, spices, and grated coconut; Sauteed: sautéed with spices
Koro	*Canavalia ensiformis*	Fabaceae	Seed	*Lodeh*	
Koro pedang	*Canavalia gladiata*	Fabaceae	Seed	*Lodeh*	
Turi	*Sesbania grandiflora*	Fabaceae	Seed, Flower	*Jangan asem*, *pecel*, and *sambal tumpeng*	*Jangan asem:* Boiled with spicy, long bean, other leaves, and tamarind; *Sambal tumpang:* Boiled leaf and young fruit with tempe busuk
Beluntas	*Pluchea indica*	Asteraceae	Leaf	*Bothok*	
Kenikir	*Cosmos caudatus*	Asteraceae	Leaf	*Urap*	
Ubi jalar	*Ipomoea batatas*	Convolvulaceae	Leaf	*Lodeh*	
Krokot	*Portulaca oleracea*	Portulacaceae	Leaf	*Jangan bening*	*Jangan bening:* Boiled with spicy luffa, other leaves, and tamarind
Katuk	*Sauropus androgynus*	Phyllanthaceae	Leaf	*Jangan bening*	
Kelor	*Moringa oleifera*	Moringaceae	Leaf	*Jangan bening*	
Mlinjo	*Gnetum gnemon*	Gnetaceae	Leaf, seed	*Jangan asem*	
Pepaya	*Carica papaya*	Caricaceae	Leaf	*Pecel* and *sambal tumpeng*	*Pecel*: Cooked salad with peanut sauce
Pisang	*Musa paradisiaca*	Musaceae	Flower	*Lodeh*, *fried*, and *sautéed*	
Lompong	*Colocasia esculenta*	Araceae	Stem	*Lodeh*	
Bambu	*Bambusa* sp.	Poaceae	Stem	*Lodeh* *(young shoot of bamboo)*	
Nangka	*Artocarpus heterophyllus*	Moraceae	Fruit	*Bobor*	*Bobor*: Boiled spices with milky coconut
Kluwih	*Artocarpus camansi*	Moraceae	Fruit	*Bobor*	
Sukun	*Artocarpus altilis*	Moraceae	Fruit	*Bobor*	
Uwi	*Dioscorea alata*	Dioscoreaceae	Tuber	Boiled	
Garut	*Maranta arundinacea*	Marantaceae	Tuber	Boiled	
Ganyong	*Canna edulis*	Cannaceae	Tuber	Boiled	
Entik	*Xanthosoma sagittifolium*	Araceae	Tuber	Boiled	
Gadung	*Dioscorea hispida*	Dioscoreaceae	Tuber	Chip	
Semanggi	*Marsilea crenata*	Marsileaceae	Leaf	*Pecel*	

Table 3. Mushroom of plant-based nutrition sources in Datengan Village, East Java, Indonesia

Local name	Latin name	Family	Parts of plant	Processed product	How to cook and serve
Jamur grigit	*Schizophyllum commune*	Schizophyllaceae	Fungus	*Bothok*	*Bothok:* Steamed with spices and grated coconut, wrapped with banana leaves
Jamur barat	*Clitocybe nebularis*	Tricholomataceae	Fungus	*Bothok*	

Table 4. Fermented food of plant-based nutrition sources in Datengan Village, East Java, Indonesia

Fermented food	Source plant	Family	Parts of plant	Processed product	How to cook and serve
Tape ketan	*Oryza sativa* var. *glutinosa*	Poaceae	Seed	Steam	Steam and wrapped with banana leaves
Tape singkong	*Manihot esculenta*	Euphorbiaceae	Tuber	Steam	

Table 5. By product of plant-based nutrition sources in Datengan Village, East Java, Indonesia

By-products	Source plant	Family	Parts of plant	Processed product	How to cook and serve
Tempe gembus	*Glycine max*	Fabaceae	Seed	Fried	
Tempe busuk	*Glycine max*	Fabaceae	Seed	*Sambal tumpang*	*Sambal tumpang:* Boiled leaf and young fruit with tempe busuk
Bekatul	*Oryza sativa*	Poaceae	Seed	*Jenang*	*Jenang*: boiled with coconut milk and palm sugar baked
Gaplek	*Manihot esculenta*	Euphorbiaceae	Tuber	Steam	
Tiwul	*Manihot esculenta*	Euphorbiaceae	Seed	Steam	
Nasi jagung	*Zea mays*	Poaceae	Seed	Steam	

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