An ethnobotanical study on the wild edible plants used by forest dwellers in Yangoupokpi Lokchao Wildlife Sanctuary, Manipur, India

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Databases and Inventories

Abstract

Background: The study documented the wild edible plants (WEPs) used by forest dwellers in the Yangoupokpi Lokchao Wildlife Sanctuary (YLWLS), Manipur, India. The inhabitants of YLWLS belong to the Thadou, Meitei, and Maring communities.

Methods: An ethnobotanical survey was carried out from March 2018 to February 2020. The elderly local people, local healers, forest staff, and vendors in local markets participated in the survey. The respondents were selected through snowball sampling method. The ethnobotanical information was gathered from the respondents, especially the elderly people, local healers, forest staff, and vendors through interviews. The questionnaire used was a semi-structured type. The data was collected on parameters such as vernacular name, botanical name, family, the life form or habit of the species, information on flowering and fruiting, the plant part used, mode of consumption, medicinal use, marketability, and price. The voucher specimens of the wild edible plants were collected and identified with the help of literature.

Results: One hundred and eight taxa belonging to 86 genera and 50 families of WEPs were documented. Zingiberaceae was the most dominant family with seven species used as WEPs. Herbs were most dominant with 42 species. Nine species bore flowers and fruits all year round. Maximum species (49 species) were consumed after cooking. Forty-nine species out of the 108 WEP species were consumed for their medicinal values. Sixty-six species (61%) of WEPs were marketed. The highest-priced species were *Asparagus racemosus* (INR 180-220/kg; USD 2.41-2.95) and *Cinnamomum verum* (INR 150-200/kg; USD 2.01-2.68). The use of the pseudostem of *Ensete glaucum* as food is a new report for Manipur.

Conclusions: The forest dwellers depend on the WEPs for their food, medicine, traditional ceremonies, and source of livelihood. Some species of WEPs could be propagated for conservation, management, and sustainable utilization, which would help in generating additional income for the locals.

Keywords: Wild edible plants, forest dwellers, Yangoupokpi Lokchao Wildlife Sanctuary, Manipur

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Background

Wild edible plants (WEPs) are those with one or more edible parts that can be used as food if collected at the appropriate growth stage and prepared appropriately (Kallas 2010). The ethnic communities have indigenous knowledge of recognizing, processing, and utilizing various edible plants (Purba & Silalahi 2021). These plants are an integral part of the regular diet, culture, and tradition of many indigenous communities of the world (Medhi *et al.* 2014). They play a significant role in the food security and livelihood of the forest dwellers and tribal communities (Yesodharan & Sujana 2007). WEPs help in enriching the diets, creating employment, and diversifying the livelihoods of communities in Teso-Karamoja region, Uganda (Ojelel *et al.* 2019). The communities in the Sikkim Himalayan region of India use 190 WEPs for food and other subsistence needs (Sundriyal & Sundriyal 2003). Most of the tribal communities residing in the Senapati district of Manipur, India, use various WEPs for their food and livelihood (Khan *et al.* 2015). Abbasi *et al.* (2013) stated that the major populace of Lesser Himalayas, Pakistan use WEPs as food and medicine for various ailments. Wild and semi-domesticated edible plants are either used in raw or processed form and contribute to the socio-economic condition and health of Zimbabweans (Maroyi 2011). These edible plants help to augment the household incomes of the communities. The wild edibles also contribute to the attainment of the sustainable development goal of eradicating poverty (Ojelel *et al.* 2019).

A country report on the plant genetic resources prepared by the National Bureau of Plant Genetic Resources (India) (2007) states around 8900 species are used by tribal communities of India of which 3900 are used as food. Around 50% of these WEP species are found in the northeastern region of India (Arora 1997). The ethnic people in the rural areas sell some WEPs in the local markets for livelihood and life support (Angami *et al.* 2006; Medhi *et al.* 2014). RBG Kew has recorded to date 7,039 edible species, in a broad taxonomic sense, from 288 families and 2,319 genera (Diazgranados *et al.* 2020). Ulian *et al.* (2020) highlighted around 102 neglected and underutilized species (NUS) of edible plants from different regions of the world, which could be key for a more resilient, sustainable, biodiverse, and community participation-driven new 'green revolution.'

Manipur is one of the eight states located in Northeast India. It lies in the geo-coordinates 23°59′N to 25°47′N latitude and 92°59′E to 94°46′E longitude, covering a total geographical area of 22,327 sq. km. (Fig.1). There are 16 districts, out of which 10 are hill districts, and six are valley districts. The Meiteis, the Nagas, and the Kukis are the larger ethnic groups of Manipur. There are about 33 recognized ethnic tribes in the state. Manipur is thus rich in both cultural and biological diversity. The state is part of the Southeast Asian Massif i.e. a cluster of adjacent mountains and high valleys within geographical Southeast Asia. It is a terrain of remarkable physical and climatic diversity. The hills of Manipur are said to have received more migrants coming from the east than from the subcontinent, connecting their cultural heritage to that of Myanmar, Tibet, and western Yunnan (Michaud *et al.* 2016). The similarity in the plant species used in these regions indicate that the usage is closely related to the traditions, environment, and cultural heritage of each region, since there is an inextricable link between cultural and biological diversity. The different communities of Manipur have deep traditional knowledge regarding the preparation of nutritionally rich food such as **champhut, hei thongba, eromba, kangshoi**, **singju**, etc. from various indigenous crop plants and forest products (Devi & Kumar 2012). Most indigenous ethnic communities depend on plant resources for their food, medicine, shelter, and livelihood. Salam *et al.* (2012) reported 46 wild leafy vegetables being sold in local markets in Ukhrul district of Manipur, while Pfoze *et al.* (2011) documented 89 wild edible plants used by the Naga and Kuki tribes of the Senapati district of Manipur. They have documented 23 species additionally used as medicinal food remedies in the study area. Devi and Salam (2016) reported 56 WEP species used by the Monsang Naga tribe of Manipur. They also mention that majority (45) are consumed as vegetables.

Materials and Methods

Study Area

Yangoupokpi Lokchao Wildlife Sanctuary (YLWLS) has rich floral and faunal diversity representing the rich Indo-Myanmar biodiversity hotspot. It was designated as a Wildlife Sanctuary on 21st March 1989. The sanctuary is situated in the Tengnoupal district of Manipur, and it covers a total geographical area of 184.80 sq. km. (Fig. 1). It lies in the 24°13′51″N to 24°26′N latitude and 94°13′51″E to 94°23′51″E longitude (Meitei *et al.* 2016). The altitude ranges from 200-900 m. The eastern boundary of the sanctuary is coterminous with the Indo-Myanmar border. The sanctuary is 110 km. from Imphal. The National Highway (NH 39) passes through the wildlife sanctuary. The Lokchao River lies in the lower western part of the sanctuary. The boundaries of the wildlife sanctuary are demarcated in the north by a stream named Wakshu Lok and the road from Sibong Village to Dolaibung Village; in the south by Lokchao River; in the east by Indo-Myanmar International Boundary Pillar No. 79 to 87 and in the west by the

Lokchao River. The Thadous, the Meiteis, and the Marings are the inhabitants living in and around the sanctuary. The communities living here have a unique culture, folklores, mythical beliefs, traditional customs, and ethnobotanical practices. Since three diverse communities were residing together in the study area, a good diversity of traditional knowledge on wild edible plants was found here. The rich ethnobotanical knowledge of the forest dwellers living in the sanctuary has not been documented previously. The present study is a first attempt to document the WEPs used by the forest dwellers in the sanctuary.

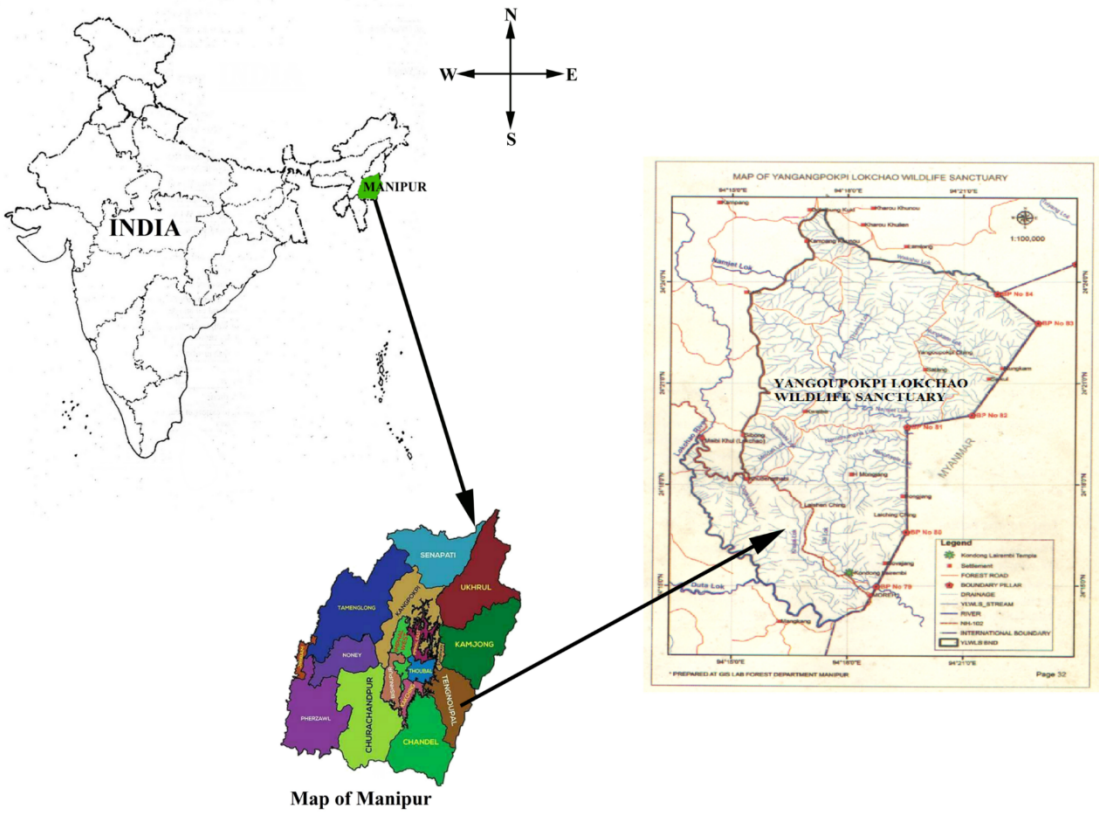

Figure 1. Location of the study area, Yangoupokpi Lokchao Wildlife Sanctuary in Manipur, India

Socio-economic characteristics

The Thadous, the Meiteis, and the Marings living in and around the forests of the sanctuary were observed to use plant resources for food, fodder, fuelwood, medicine, and traditional beliefs during the present study. Most of the inhabitants of the sanctuary earn their living through farming or as labourers. Since the inhabitants live deep inside the forest, they depend on the plants growing near their settlements and surrounding areas. WEPs growing in their surrounding areas are also a source of livelihood and additional income. The inhabitants practice shifting cultivation for livelihood (Bungnamei & Saikia 2020). Fermented bamboo shoots (locally known as **soibum**) was prepared and sold in the local markets by people belonging to the Meitei community of Kwatha Village.

Methods

An ethnobotanical survey was carried out from March 2018 to February 2020 among the forest dwellers living in the sanctuary. The respondents were selected using snowball sampling technique. Prior Informed Consent (PIC) was taken from the respondents before recording the information. The ethnobotanical information was gathered from the respondents, especially the elderly people, local healers, forest staff, and vendors through interviews. The questionnaire used was a semi-structured type (Appendix 1). Surveys were conducted in Bongjang, Govajang, H Mongjang, Kambang/Kampang Khunou, Kwatha, Kwatha Khunou, Lokchao, Satang and Sibong areas. Data was collected on important taxonomic parameters such as vernacular names (Maring, Meitei, and Thadou languages), botanical names, and family. The ecological parameters noted were the life form or habit of the species and information on flowering and fruiting. The economic parameters recorded were the plant part used, mode of consumption, medicinal uses, marketability, and price of marketed species in the local market. The conservation status of the edible plant species was studied by referring to the IUCN Red List (2020). Voucher specimens of the WEPs were collected and preserved by following Jain and Rao (1977). The species were identified with the help of

relevant literature. The herbarium specimens were housed in ASSAM. The current nomenclature of each species was determined by referring to databases such as Plants of the World Online (http://www.plantsoftheworldonline.org), Tropicos (https://tropicos.org), and the World Flora Online (http://www.worldfloraonline.org). The collected data was further analyzed and presented using tables and figures.

Results

Taxonomic diversity

A total of 108 taxa of WEPs belonging to 86 genera and 50 families were documented during the present study. The most dominant families include Zingiberaceae with seven species followed by Moraceae, Poaceae, Polygonaceae, Rubiaceae with five species each; Amaranthaceae, Arecaceae, Lamiaceae, Phyllanthaceae, Rosaceae with four species each; Clusiaceae, Fabaceae, Dioscoreaceae, Rutaceae, Solanaceae with three species each; Alismataceae, Apiaceae, Araceae, Araliaceae, Asteraceae, Combretaceae, Cyperaceae, Dilleniaceae, Lauraceae, Lythraceae, Musaceae with two species each and rest of 24 families having only one species (Fig. 2). The documented species are listed in alphabetical order (Table 1). The botanical name, voucher number, vernacular name (if available), family, habit, IUCN Red List Category, flowering & fruiting phenology, the part used, mode of consumption, medicinal use, and market value have also been provided. The photographs of some WEPs are also given (Fig. 3 & Fig. 4).

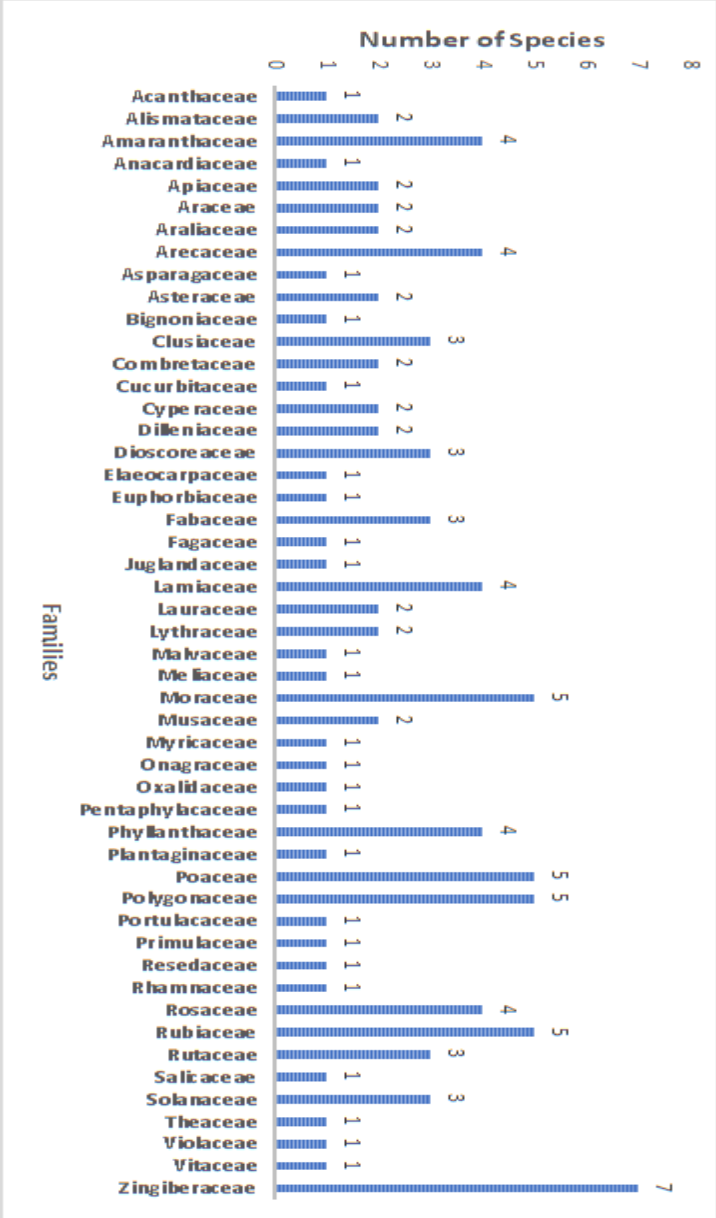

Figure 2. Analysis of wild edible plant families

Table 1. List of wild edible plants used by the forest dwellers in Yangoupokpi Lokchao Wildlife Sanctuary, Manipur, India.

Family	Botanical Name and Voucher number	Vernacular Name	Habit	IUCN Category	Flowering & Fruiting Phenology	Edible part used	Mode of consumption	Medicinal use	Market value (INR)/(USD)
Asteraceae	*Acmella paniculata* (Wall. ex DC.) R.K. Jansen LRM 137428	**Ansache** (Th)	Herb	LC	Apr.-Dec.	Leaf	Cooked as vegetable.	Flowers paste is used in toothache, sore mouth, throat infection, and stammering.	Not marketed
Alismataceae	*Alisma plantago-aquatica* L. LRM 137527	**Kaothum** (Me)	Herb	LC	May-Sept.	Tuber, young shoot	Young shoots are cooked. Tubers are eaten raw or boiled.	Not reported	INR 80-120/kg (USD 1.07-1.60)
Araceae	*Alocasia macrorrhizos* (L.) G.Don LRM 137539	**Honggu** (Me)	Herb	NE	Aug.-Jan.	Leaf, petiole, rhizome	Leaves, petioles, and rhizomes are cooked. Petioles are used as an ingredient of **Hentak**.	Juice of rhizome is taken for healing wounds and poisonous bites.	Not marketed
Zingiberaceae	*Alpinia galanga* (L.) Willd. LRM 137503	**Ramrhou** (Ma) & **Kanghu** (Me)	Herb	NE	May-Sept.	Whole plant	Young shoots, flowers, and rhizomes are cooked as vegetables.	Extract of inflorescence is gargled for treatment of tonsillitis. Leaves are used as antiseptic and astringent. Extract of rhizome is used in treatment of cough, dysentery, fever, intestinal worms, and piles.	INR 50-70/kg (USD 0.67-0.94)
Zingiberaceae	*Alpinia nigra* (Gaertn.) Burtt LRM 137418	**Pullei** (Me)	Herb	LC	May-Aug.	Whole plant	Young shoots, flowers, and rhizomes are cooked as **Eromba**.	Boiled rhizome is eaten in treatment of cough and fever.	INR 50-70/kg (USD 0.67-0.94)
Amaranthaceae	*Alternanthera philoxeroides* (Mart.) Griseb. LRM 137502	**Kabo-napi** (Me)	Herb	NE	May-Nov.	Leaf, stem	Cooked as vegetable.	Not reported	Not marketed
Amaranthaceae	*Alternanthera sessilis* (L.) R.Br. ex DC. LRM 137495	**Phakchet** (Me)	Herb	LC	Apr.-Oct.	Young shoot	Cooked as vegetable.	Boiled leaves and shoots are eaten in treatment of boils, bronchitis, and diabetes.	Not marketed
Amaranthaceae	*Amaranthus spinosus* L. LRM 137512	**Chengkruk** (Me)	Herb	NE	May-Oct.	Leaf, young shoot	Cooked as vegetable.	Boiled leaves and shoots are eaten in treatment of blood pressure, diabetes, and liver problems.	Not marketed
Amaranthaceae	*Amaranthus viridis* L. LRM 137515	**Chengkruk** (Me)	Herb	NE	Year-round	Leaf, young shoot	Cooked as vegetable.	Shoots are used in treatment of poisonous bites.	INR 30-50/kg (USD 0.40-0.67)

Zingiberaceae	*Amomum dealbatum* Roxb. LRM 137482	-	Herb	DD	March-Aug.	Flower bud, young shoot	Cooked as vegetable.	Not reported	INR 60-80/kg (USD 0.80- 1.07)
Phyllanthaceae	*Antidesma acidum* Retz. LRM 137505	**Ching Heiyen** (Me)	Shrub	LC	May-Nov.	Fruit, leaf, young shoot	Young shoots, leaves, and ripe fruits are eaten raw. Leaves are cooked as vegetable.	Boiled leaves and young shoots are eaten in treatment of stomach problems. Boiled leaves extract is used in diabetes.	INR 50-70/kg (USD 0.67-0.94)
Araliaceae	*Aralia armata* (Wall. ex G.Don) Seem. LRM 137532	**Naosek Nambi** (Me)	Shrub	LC	Aug.-Dec.	Fruit, leaf	Eaten raw or cooked as vegetable.	Leaves are eaten in asthma.	INR 40-60/kg (USD 0.54-0.80)
Araceae	*Arisaema tortuosum* (Wall.) Schott LRM 137431	-	Herb	NE	June-Sept.	Tuber, young shoot	Cooked as vegetable.	Decoction of rhizome is used in treatment of snake bite.	Not marketed
Moraceae	*Artocarpus lacucha* Buch.-Ham. LRM 137435	**Heirikokthong** (Me)	Tree	NE	March-Oct.	Fruit	Unripe fruits are cooked as vegetables and ripe fruits are eaten raw.	Boiled bark extract is used in diabetes. Ripe fruit is taken in fever and stomach problems.	INR 30-50/kg (USD 0.40-0.67)
Asparagaceae	*Asparagus racemosus* Willd. LRM 137457	**Nunggarei** (Me)	Climber	NE	Oct.-Jan.	Tuber, young shoot	Young shoots are eaten raw or cooked. Tubers are cooked.	Whole plant is used in treatment of arthritis, cough, diabetes, diarrhoea, dysentery, piles and urinary disorders.	INR 180-220/kg (USD 2.41-2.95)
Phyllanthaceae	*Baccaurea ramiflora* Lour. LRM 137497	**Motok Hei** (Me)	Tree	LC	March-Aug.	Fruit	Eaten raw.	Bark is used in treatment of skin diseases.	INR 30-50/kg (USD 0.40-0.67)
Poaceae	*Bambusa tulda* Roxb. LRM 137531	**Utang** (Me)	Bamboo	NE	-	Young shoot	Young shoots are cooked as **Usoi Utti** and **Usoi Kangsu**.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Fabaceae	*Bauhinia variegata* L. LRM 137544	**Chingthrao** (Me)	Tree	LC	Sept.-Apr.	Flower	Eaten raw or cooked as vegetable.	Not reported	Not marketed
Phyllanthaceae	*Bischofia javanica* Blume LRM 137432	**Uthum Naraobi** (Me)	Tree	LC	Apr.-Sept.	Fruit, leaf, young shoot	Young shoots and tender leaves are cooked as vegetable. Ripe fruits are eaten raw.	Not reported	INR 50-70/kg (USD 0.67-0.94)
Araliaceae	*Brassaiopsis hainla* (Buch.-Ham.) Seem. LRM 137470	-	Tree	NE	Jan.-Aug.	Leaf, young shoot	Cooked as vegetable.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Arecaceae	*Calamus floribundus* Griff. LRM 137480	**Lee** (Me)	Shrub	NE	Jan.-June	Fruit, stem pith, young shoot	Young shoots and soft stem piths are cooked as vegetable. Ripe fruits are eaten raw.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Arecaceae	*Calamus latifolius* Roxb. LRM 137483	**Lee-ren** (Me)	Shrub	LC	Jan.-June	Fruit, stem pith, young shoot	Young shoots and soft stem piths are cooked as vegetable.	Not reported	INR 40-60/kg (USD 0.54-0.80)

							Ripe fruits are eaten raw.		
Arecaceae	*Caryota urens* L. LRM 137411	**Lamgi kwa** (Me)	Tree	LC	Year-round	Stem pith	Soft stem piths are cooked as vegetable.	Not reported	Not marketed
Fagaceae	*Castanopsis tribuloides* (Sm.) A.DC. LRM 137453	**U-Thangji** (Me)	Tree	NE	May-Nov.	Nut	Roasted nuts are eaten.	Not reported	INR 60-80/kg (USD 0.80- 1.07)
Apiaceae	*Centella asiatica* (L.) Urb. LRM 137504	**Alaiphon** (Ma), **Peruk** (Me) & **Changkongche** (Th)	Herb	LC	March-Sept.	Whole plant	Eaten raw or cooked as vegetable.	Whole plant extract is used in treatment of hypertension, sores and wounds. It is taken with honey in fever, gastric and stomach problems.	INR 50-70/kg (USD 0.67-0.94)
Poaceae	*Chimonobambusa callosa* (Munro) Nakai LRM 137501	**Laiwa** (Me)	Bamboo	NE	-	Young shoot	Young shoots are cooked as vegetable.	Not reported	INR 50-80/kg (USD 0.67-1.07)
Lauraceae	*Cinnamomum verum* J. Presl LRM 137481	**Usingsha** (Me)	Tree	NE	March-Sept.	Bark, leaf	Used as a spice.	Bark is astringent and carminative. Fruits and leaves are used in treatment of cough and fever.	INR 150-200/kg (USD 2.01-2.68)
Vitaceae	*Cissus discolor* Blume LRM 137516	**Kongngouyen Laba** (Me)	Climber	NE	July-Nov.	Leaf, young shoot	Cooked as vegetable.	Not reported	INR 50-70/kg (USD 0.67-0.94)
Lamiaceae	*Clerodendrum glandulosum* Lindl. LRM 137449	**Anphui** (Th) & **Kuthap** (Me)	Shrub	NE	Aug.-Dec.	Leaf	Cooked as vegetable.	Flowers, leaves, and shoots are eaten fresh or cooked in treatment of hypertension. Decoction of leaves is used in piles. Leaves are used in cough, diabetes, diarrhoea, dysentery, rheumatic pain, and skin diseases.	INR 30-50/kg (USD 0.40-0.67)
Asteraceae	*Crassocephalum crepidioides* (Benth.) S. Moore LRM 137442	**Tera Paibi** (Me)	Herb	NE	July-Dec.	Young shoot	Cooked as vegetable.	Decoction of plants is applied on burns, cuts, and wounds. Cooked shoots are eaten for stomach disorders and ulcer.	Not marketed
Cucurbitaceae	*Cucumis maderaspatanus* L. LRM 137487	**Ram Machangei** (Ma) & **Lam-thabi** (Me)	Climber	NE	March-Nov.	Fruit, leaf, young shoot	Eaten raw or cooked.	Not reported	Not marketed
Zingiberaceae	*Curcuma angustifolia* Roxb. LRM 137479	**Yaipan** (Me)	Herb	NE	March-July	Inflorescence	Cooked as vegetable.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Cyperaceae	*Cyperus esculentus* L. LRM 137533	-	Sedge	LC	May-Oct.	Tuber	Eaten raw or boiled.	Not reported	INR 60-80 /kg (USD 0.80- 1.07)

Cyperaceae	*Cyperus rotundus* L. LRM 137522	**Sembang Kaothum** (Me)	Sedge	LC	May-Oct.	Tuber	Eaten raw or boiled.	Rhizome is used in treatment of fever and stomach disorders.	Not marketed
Poaceae	*Dendrocalamus hookeri* Munro LRM 137514	**Watankhoi** (Me)	Bamboo	NE	-	Young shoot	Cooked as **Usoi Utti** and **Usoi Kangsu**.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Dilleniaceae	*Dillenia indica* L. LRM 137511	**Heigri** (Me)	Tree	LC	May-Dec.	Fruit	Fruit pulps are eaten raw or cooked.	Fruits are eaten as a digestive and also used in dandruffs and hair fall problems.	INR 30-50/kg (USD 0.40-0.67)
Dilleniaceae	*Dillenia pentagyna* Roxb. LRM 137478	**Larong** (Me)	Tree	NE	Apr.-Oct.	Flower bud, fruit	Eaten raw or cooked.	Fruits are eaten as a digestive and also used in stomach disorders and swellings.	INR 30-50/kg (USD 0.40-0.67)
Dioscoreaceae	*Dioscorea alata* L. LRM 137456	**Ha** (Me)	Climber	NE	Oct.-Feb.	Tuber	Eaten boiled or cooked as vegetable.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Dioscoreaceae	*Dioscorea bulbifera* L. LRM 137458	**Ha** (Me)	Climber	NE	July-Jan.	Tuber	Eaten boiled or cooked as vegetable.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Dioscoreaceae	*Dioscorea pentaphylla* L. LRM 137530	**Ha** (Me)	Climber	NE	July-Jan.	Tuber	Eaten boiled or cooked as vegetable.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Rosaceae	*Docynia indica* (Colebr. ex Wall.) Decne. LRM 137414	**Heitup** (Me)	Tree	NE	March-Sept.	Fruit	Eaten raw or pickled.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Meliaceae	*Dysoxylum excelsum* Blume LRM 137535	-	Tree	NE	Sept.-March	Flower, leaf	Cooked as vegetable.	Not reported	Not marketed
Elaeocarpaceae	*Elaeocarpus floribundus* Blume LRM 137451	**Chorphon** (Me)	Tree	NE	July-Feb.	Fruit	Eaten raw, cooked as fruit curry **Hei Thongba** or pickled.	Leaves are used in treatment of piles.	INR 30-50/kg (USD 0.40-0.67)
Musaceae	*Ensete glaucum* (Roxb.) Cheesman LRM 137468	-	Herb	LC	Year-round	Pseudostem	Cooked as vegetable.	Not reported	Not marketed
Euphorbiaceae	*Euphorbia hirta* L. LRM 137445	**Pakhangba Leiton** (Me)	Herb	NE	May-Nov.	Leaf, young shoot	Eaten raw or cooked.	Whole plant is used in treatment of asthma, diarrhoea, dysentery, piles, and skin diseases.	Not marketed
Pentaphylacaceae	*Eurya acuminata* DC. LRM 137529	**Uyangan** (Me)	Tree	NE	Aug.-Dec.	Leaf, young shoot	Cooked as vegetable.	Not reported	Not marketed
Rubiaceae	*Exallage auricularia* (L.) Bremek. LRM 137491	**Langban Koukha** (Me)	Herb	NE	March-Dec.	Young shoot	Eaten raw or cooked.	Not reported	Not marketed
Polygonaceae	*Fagopyrum esculentum* Moench LRM 137421	**Wakha Yendem** (Me)	Herb	NE	March-Oct.	Young shoot	Cooked as vegetable.	Cooked shoots are eaten in treatment of diabetes and high blood pressure.	Not marketed

Moraceae	*Ficus auriculata* Lour. LRM 137496	**Heibong** (Me)	Tree	LC	Feb.-Nov.	Fruit, leaf, young shoot	Fruits are eaten raw. Young shoots, tender leaves, and young fruits are cooked as vegetable.	Bark and fruits are used in diabetes, diarrhoea, dysentery, and lung diseases.	INR 30-50/kg (USD 0.40-0.67)
Moraceae	*Ficus hispida* L.f. LRM 137488	**Ashi Heibong** (Me)	Tree	LC	May-Sept.	Fruit	Fruits are eaten raw.	Not reported	Not marketed
Moraceae	*Ficus racemosa* L. LRM 137427	**Heibong** (Me), **Channahei** (Ma) & **Theichang** (Th)	Tree	LC	Apr.-Dec.	Fruit, leaf, young shoot	Fruits are eaten raw. Young shoots, tender leaves, and young fruits are cooked as vegetable.	Bark is used in insect bites and skin diseases. Fresh leaves and fruits are eaten in treatment of dysentery, diabetes, and lung diseases.	INR 30-50/kg (USD 0.40-0.67)
Moraceae	*Ficus semicordata* Buch.-Ham. ex Sm. LRM 137499	**Heiri** (Me)	Tree	LC	Year-round	Fruit	Eaten raw and cooked as vegetable.	Not reported	INR 30-50/kg (USD 0.40-0.67)
Salicaceae	*Flacourtia jangomas* (Lour.) Raeusch. LRM 137513	**Heitroi** (Me)	Tree	NE	March-Sept.	Fruit	Eaten raw or pickled.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Clusiaceae	*Garcinia cowa* Roxb. ex Choisy LRM 137509	**Heibung** (Me)	Tree	NE	Apr.-Sept.	Fruit	Eaten raw.	Not reported	Not marketed
Clusiaceae	*Garcinia pedunculata* Roxb. ex Buch.-Ham. LRM 137462	**Heibung** (Me)	Tree	NE	Sept.-Feb.	Fruit	Eaten raw or cooked as **Hei thongba**.	Fruits are eaten to cure stomach disorders and jaundice.	INR 40-70/kg (USD 0.54-0.94)
Clusiaceae	*Garcinia xanthochymus* Hook.f. ex T.Anderson LRM 137524	**Heirangkhoi** (Me)	Tree	NE	March-Oct.	Fruit	Eaten raw.	Fruits are eaten to cure stomach disorders.	INR 30-50/kg (USD 0.40-0.67)
Malvaceae	*Grewia asiatica* L. LRM 137426	**Sanjelhei** (Me)	Shrub	LC	May-Dec.	Fruit	Eaten raw.	Not reported	Not marketed
Zingiberaceae	*Hedychium coronarium* J.Koenig LRM 137439	**Loklei** (Me)	Herb	DD	July-Dec.	Rhizome, young shoot	Cooked as **Eromba**.	Rhizome is used in treatment of cough, vomiting, and piles.	INR 50-70/kg (USD 0.67- 0.94)
Zingiberaceae	*Hedychium ellipticum* Buch.-Ham. ex Sm. LRM 137424	-	Herb	NE	May-Oct.	Rhizome, young shoot	Cooked as vegetable.	Not reported	Not marketed
Zingiberaceae	*Hedychium spicatum* Sm. LRM 137438	**Takhellei Hangampal** (Me)	Herb	NE	July-Dec.	Rhizome, young shoot	Cooked as vegetable.	Not reported	Not marketed
Juglandaceae	*Juglans regia* L. LRM 137520	**Heijuga** (Me)	Tree	LC	May-Oct.	Cotyledon	Eaten raw.	Fruits are eaten in treatment of heart diseases and leaves are used for diarrhoea, fever, and joint pains.	INR 80-120/kg (USD 1.07-1.60)
Rubiaceae	*Knoxia roxburghii* (Spreng.) M.A.Rau LRM 137538	**Meitei Lembum** (Me)	Herb	NE	Aug.-Dec.	Leaf, young shoot	Cooked as vegetable.	Not reported	Not marketed

Fabaceae	*Leucaena leucocephala* (Lam.) de Wit LRM 137543	**Chingonglei** (Me)	Shrub	NE	Aug.-Feb.	Pod	Eaten raw and used as an ingredient of **Singju**.	Leaves are used in treatment of diabetes and piles.	INR 50-70/kg (USD 0.67-0.94)
Lamiaceae	*Leucas aspera* (Willd.) Link LRM 137407	**Mayanglambum** (Me)	Herb	NE	Year-round	Young shoot	Cooked as vegetable.	Whole plant is antiseptic. Flowers and leaves extract mixed with honey is taken in cold, cough, and fever.	Not marketed
Lauraceae	*Litsea cubeba* (Lour.) Pers. LRM 137422	**Usingsa**, **Ngairong** (Me)	Tree	NE	Nov.-July	Flower, fruit, leaf	Flowers and fruits are eaten raw. Ripe fruits and leaves are used as spice.	Flowers and fruits are eaten in throat infection. Bark, fruits, and leaves are used in diarrhoea, dysentery, and rheumatism.	INR 100-120/kg (USD 1.34-1.61)
Onagraceae	*Ludwigia adscendens* (L.) H.Hara LRM 137475	**Esing Kundo** (Mi)	Herb	NE	Feb.-Oct.	Young shoot	Eaten raw or cooked.	Not reported	Not marketed
Primulaceae	*Lysimachia candida* Lindl. LRM 137473	**Kengoi** (Mi)	Herb	NE	Apr.-July	Young shoot	Cooked as vegetable.	Not reported	INR 80-120/kg (USD 1.07- 1.61)
Poaceae	*Melocanna baccifera* (Roxb.) Kurz LRM 137485	**Moubi-wa** (Me)	Bamboo	NE	_	Young shoot	Cooked as vegetable.	Not reported	INR 30-50/kg (USD 0.40-0.67)
Rubiaceae	*Meyna spinosa* Roxb. ex Link LRM 137494	**Heibi** (Me)	Tree	NE	Apr.-Sept.	Fruit, leaf	Eaten raw.	Fruits and leaves are eaten for treatment of intestinal worms. Fruits extract is taken in diabetes.	INR 30-50/kg (USD 0.40-0.67)
Musaceae	*Musa balbisiana* Colla LRM 137467	**Laphu** (Ma, Me) & **Changlon**g (Th)	Herb	LC	-	Flower, fruit, pseudostem	Cooked as **Eromba** or used as an ingredient of **Singju**.	Not reported	INR 15-25/kg (USD 0.20-0.33)
Myricaceae	*Myrica esculenta* Buch.-Ham. ex D. Don LRM 137510	**Nongang Hei** (Me)	Tree	NE	July-Dec.	Fruit	Eaten raw or pickled.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Apiaceae	*Oenanthe javanica* (Blume) DC. LRM 137517	**Komprek** (Me)	Herb	LC	July-Oct.	Whole plant	Eaten raw or cooked as vegetable.	Not reported	INR 50-80/kg (USD 0.67-1.07)
Bignoniaceae	*Oroxylum indicum* (L.) Kurz. LRM 137448	**Shamba** (Me) & **Bahlong** (Th)	Tree	NE	July-Feb.	Pod, young shoot	Tender pods and young shoots are cooked as vegetable.	Bark is used in treatment of diabetes, muscular pain, piles, and wounds.	INR 30-50/kg (USD 0.40-0.67)
Oxalidaceae	*Oxalis corniculata* L. LRM 137417	**Ram Ansur** (Ma) & **Yensin** (Mi)	Herb	NE	Year-round	Flower, leaf	Eaten raw or cooked.	Whole plant extract is taken to cure stomach ailments.	Not marketed
Rubiaceae	*Paederia foetida* L. LRM 137537	**Oinam** (Me)	Climber	NE	Sept.-Jan.	Leaf, young shoot	Cooked as vegetable.	Not reported	Not marketed
Polygonaceae	*Persicaria barbata* (L.)H.Hara. LRM 137523	**Yelang** (Me)	Herb	LC	Aug.-Dec.	Leaf, young shoot	Cooked as vegetable.	Not reported	INR 60-80/kg (USD 0.80- 1.07)

Polygonaceae	*Persicaria chinensis* (L.) H. Gross LRM 137447	**Angom Yensil** (Me)	Herb	NE	Year-round	Leaf, young shoot	Cooked as vegetable.	Not reported	Not marketed
Polygonaceae	*Persicaria hydropiper* (L.) Delarbre LRM 137425	**Chaokhong** (Me)	Herb	LC	May-Sept.	Leaf, young shoot	Cooked as vegetable.	Not reported	Not marketed
Polygonaceae	*Persicaria posumbu* (Buch.-Ham. ex D.Don) H.Gross LRM 137506	**Phak-pai** (Me)	Herb	NE	May-Oct.	Leaf, young shoot	Eaten raw with **Eromba**.	Not reported	INR 50-70/kg (USD 0.67- 0.94)
Acanthaceae	*Phlogacanthus curviflorus* (Nees) Nees LRM 137410	**Lamgi Nongmangkha** (Me)	Shrub	NE	Feb.-May	Flower	Cooked as vegetable.	Boiled leaves juice is taken in cough and fever.	Not Marketed
Arecaceae	*Phoenix loureiroi* Kunth LRM 137526	**Thangtup** (Me)	Shrub	NE	July-Dec.	Fruit	Eaten raw.	Not reported	INR 30-50/kg (USD 0.40-0.67)
Phyllanthaceae	*Phyllanthus urinaria* L. LRM 137436	**Chakpa-heikru** (Me) & **Sohlhu** (Th)	Herb	NE	July-Dec.	Young shoot	Eaten raw or cooked.	Whole plant is used in treatment of boils, leucoderma, and skin diseases.	Not marketed
Solanaceae	*Physalis angulata* L. LRM 137490	**Morok Poklaobi** (Me)	Herb	NE	March-Sept.	Fruit	Eaten raw.	Not reported	Not marketed
Plantaginaceae	*Plantago asiatica* subsp. *erosa* (Wall.) Z. Yu Li LRM 137416	**Yempat** (Me)	Herb	NE	March-Oct.	Whole plant	Cooked as vegetable.	Warmed fresh leaf is applied on boils.	Not Marketed
Portulacaceae	*Portulaca oleracea* L. LRM 137437	**Leibak Kundo** (Me)	Herb	NE	June-Dec.	Whole plant	Eaten raw or cooked.	Not reported	Not marketed
Rosaceae	*Potentilla indica* (Andrews) Th.Wolf LRM 137484	**Kakyen Khujin Laba** (Me)	Herb	NE	Year-round	Fruit	Eaten raw.	Whole plant is used in treatment of stone formation in kidneys and urinary tracts.	Not marketed
Rosaceae	*Pyrus pashia* Buch.-Ham. ex D.Don LRM 137525	**Lam Naspati** (Me)	Tree	LC	Apr.-Oct.	Fruit	Eaten raw.	Not reported	INR 30-50/kg (USD 0.40-0.67)
Rhamnaceae	*Rhamnus napalensis* (Wall.) M.A. Lawson LRM 137521	**Ching-boroi** (Me)	Shrub	LC	May-Nov.	Fruit	Eaten raw.	Not reported	Not marketed
Anacardiaceae	*Rhus chinensis* Mill. LRM 137452	**Heimang** (Me) & **Khongma** (Th)	Tree	LC	Aug.-Jan.	Fruit	Eaten raw or as pounded powder.	Fruits are eaten in indigestion and urinary disorders.	INR 30-50/kg (USD 0.40-0.67)
Lythraceae	*Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne LRM 137474	**Ishing-Kundo** (Me)	Herb	LC	Apr.-Dec.	Young shoot	Cooked as vegetable.	Whole plant is used in treatment of urinary disorders.	Not marketed
Lamiaceae	*Rotheca serrata* (L.) Steane & Mabb. LRM 137446	**Moirang Khanam** (Me)	Shrub	NE	June-Dec.	Inflorescence, young shoot	Cooked as vegetable.	Leaves are used in indigestion and stomach disorders.	INR 40-60/kg (USD 0.54-0.80)

Rosaceae	*Rubus ellipticus* Sm. LRM 137409	**Heijampet Manbi** (Me)	Shrub	NE	March-July	Fruit	Eaten raw.	Fruits and roots are used in treatment of diarrhoea and dysentery.	Not marketed
Alismataceae	*Sagittaria sagittifolia* L. LRM 137536	**Koukha** (Me)	Herb	LC	May-Nov.	Tuber	Eaten cooked.	Not reported	INR 100-150/kg (USD 1.34-2.01)
Theaceae	*Schima wallichii* (DC.) Korth. LRM 137406	**Usoi** (Me) & **Khieng** (Th)	Tree	LC	March-Nov.	Leaf	Eaten raw or cooked.	Not reported	Not marketed
Fabaceae	*Senegalia pennata* (L.) Maslin LRM 137444	**Khang** (Me) & **Khangkhuh** (Th)	Climber	NE	Aug.-Jan.	Leaf, young shoot	Eaten raw and as a fried vegetable.	Not reported	INR 100-120/kg (USD 1.34-1.61)
Solanaceae	*Solanum nigrum* L. LRM 137500	**Morokpan** (Me) & **Anjouche** (Th)	Herb	NE	March-Nov.	Fruit, leaf	Cooked as vegetable.	Not reported	Not marketed
Solanaceae	*Solanum torvum* Sw. LRM 137423	**Sing Khanga** (Me)	Shrub	NE	Year-round	Fruit	Unripe fruits are cooked as vegetable.	Roasted or cooked fruits are eaten in treatment of diabetes.	INR 30-50/kg (USD 0.40-0.67)
Resedaceae	*Stixis suaveolens* (Roxb.) Baill. LRM 137489	**Urirei** (Me)	Liana	NE	March-Nov.	Fruit	Eaten raw.	Not reported	Not marketed
Combretaceae	*Terminalia chebula* Retz. LRM 137528	**Manahi** (Me)	Tree	NE	Apr.-Nov.	Fruit	Fresh or dried fruits are eaten raw.	Fruits are used in treatment of cold, cough, gastric problems, ulcers, and piles.	INR 100-150/kg (USD 1.34-2.01)
Combretaceae	*Terminalia citrina* (Gaertn.) Roxb. LRM 137443	**Manahi** (Me)	Tree	LC	May-Dec.	Fruit	Fresh or dried fruits are eaten raw.	Fruits are used in treatment of cold, cough, gastric problems, ulcers, and piles.	INR 100-150/kg (USD 1.34-2.01)
Lythraceae	*Trapa natans* L. LRM 137492	**Heikak** (Me)	Herb	LC	Apr.-Oct.	Nut, petiole	Nuts inside the fruits and petioles are eaten raw or cooked.	Not reported	INR 40-60/kg (USD 0.54-0.80)
Violaceae	*Viola pilosa* Blume LRM 137476	**Huikhong** (Me)	Herb	NE	March-Sept.	Whole plant	Eaten raw or cooked.	Not reported	INR 30-50/kg (USD 0.40-0.67)
Lamiaceae	*Vitex negundo* L. LRM 137408	**Warek-lou** (Ma) & **Urik Shibi** (Me)	Shrub	LC	Feb.-Aug.	Leaf, young shoot	Cooked as vegetable.	Not reported	Not marketed
Rubiaceae	*Wendlandia glabrata* DC. LRM 137464	**Pheija** (Me)	Tree	NE	Oct.-June	Inflorescence	Eaten raw or cooked as vegetable.	Not reported	INR 120-150/kg (USD 1.61-2.01)
Rutaceae	*Zanthoxylum acanthopodium* DC. LRM 137477	**Singdi** (Ma) & **Mukthrubi** (Me)	Shrub	LC	March-Oct.	Flower, fruit, leaf	Fruits are used as spice. Tender leaves are eaten raw or cooked.	Leaves and seeds are used in treatment of asthma, cold, cough, and fever. Seeds oil is used in toothache and rheumatism.	INR 100-150/kg (USD 1.34-2.01)
Rutaceae	*Zanthoxylum armatum* DC.	**Singdi** (Ma) & **Mukthrubi** (Me)	Shrub	LC	Feb.-July	Fruit, leaf	Fruits are used as spice. Tender leaves	Leaves and seeds are used in treatment of asthma,	INR 100-150/kg (USD 1.34-2.01)

	LRM 137415						are eaten raw or cooked.	cold, cough, and fever. Seeds oil is used in toothache and rheumatism.	
Rutaceae	*Zanthoxylum rhetsa* (Roxb.) DC. LRM 137493	**Ngang** (Me)	Tree	LC	March-Oct.	Fruit, leaf	Fruits are used as spice. Tender leaves are cooked.	Leaves and seeds are used in treatment of asthma, cold, cough, and fever. Seeds oil is used in toothache and rheumatism.	INR 100-150/kg (USD 1.34-2.01)
Poaceae	*Zizania latifolia* (Griseb.) Hance ex F. Muell. LRM 137542	**Ishing Kambong** (Me)	Grass	NE	June-Dec.	Fruit	Eaten raw or cooked.	Not reported	INR 80-120/kg (USD 1.07- 1.61)

Note: Vernacular Name: Ma=Maring, Me=Meitei and Th=Thadou. **IUCN Red List Category**: DD=Data Deficient, LC= Least Concern and NE= Not Evaluated (Note: 1 INR = 0.01341 USD in 05th January 2022 from www.exchange-rates.org)

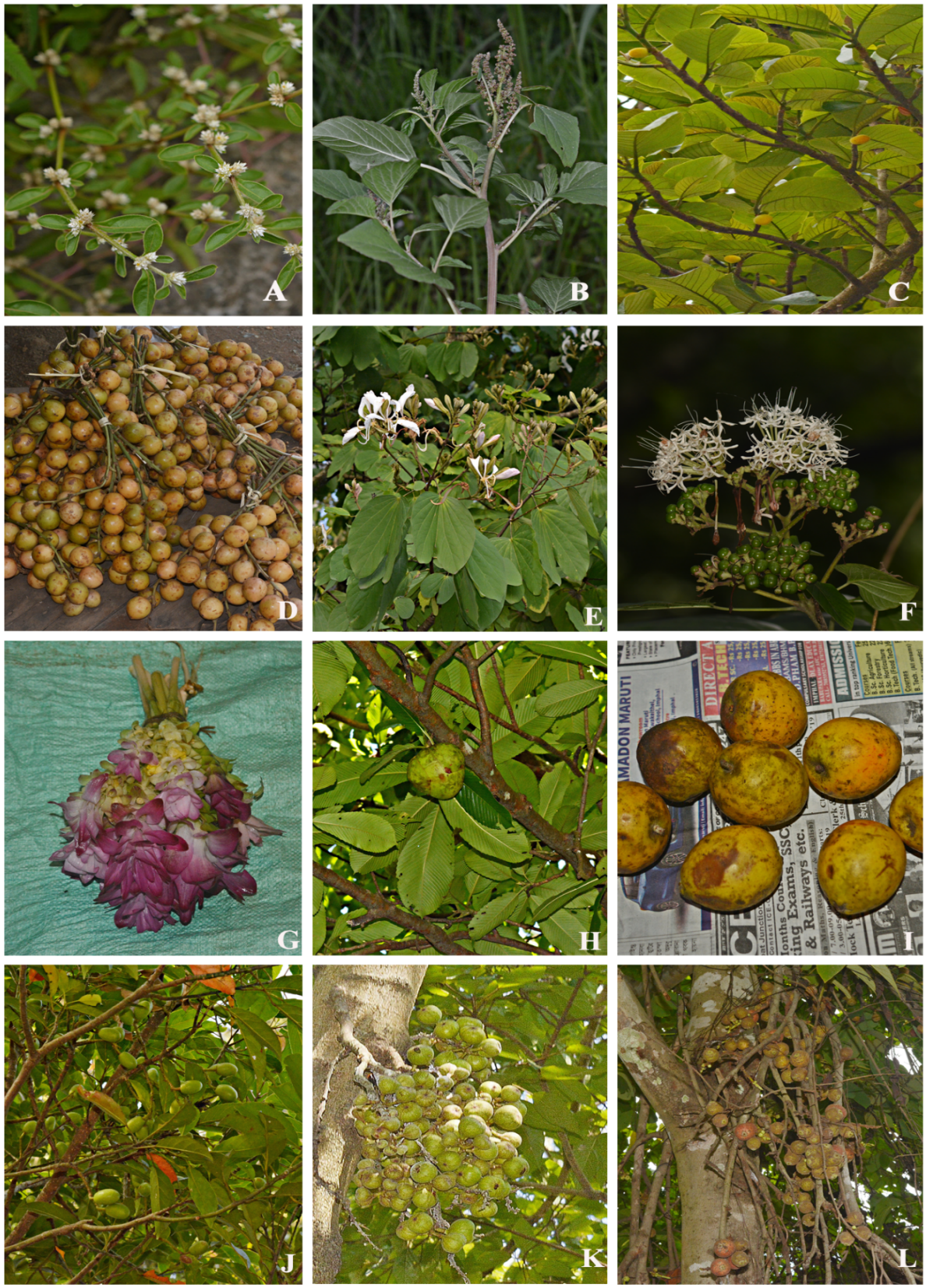

Figure 3. Some wild edible plants used by the forest dwellers of Yangoupokpi Lokchao Wildlife Sanctuary. A. *Alternanthera sessilis* (L.) R.Br. ex DC., B. *Amaranthus viridis* L., C. *Artocarpus lacucha* Buch.-Ham., D. *Baccaurea ramiflora* Lour., E. *Bauhinia variegata* L., F. *Clerodendrum glandulosum* Colebr. ex Wall., G. *Curcuma angustifolia* Roxb., H. *Dillenia indica* L., I. *Docynia indica* (Colebr. ex Wall.) Decne., J. *Elaeocarpus floribundus* Blume, K. *Ficus racemosa* L. & L. *Ficus semicordata* Buch.–Ham. ex Sm.

Figure 4. Some wild edible plants used by the forest dwellers of Yangoupokpi Lokchao Wildlife Sanctuary. A. *Hedychium coronarium* J.Koenig, B. *Litsea cubeba* (Lour.) Pers., C. *Myrica esculenta* Buch.–Ham. ex D. Don, D. *Rhus chinensis* Mill., E. *Rotheca serrata* (L.) Steane & Mabb., F. *Rubus ellipticus* Sm., G. *Sagittaria sagittifolia* L., H. *Solanum nigrum* L., I. *Solanum torvum* Sw., J. *Wendlandia glabrata* DC., K. *Zanthoxylum armatum* DC. & L. *Zizania latifolia* (Griseb.) Hance ex F. Muell.

Life forms

It was observed that herbs were most dominant with 42 species, followed by trees (34), shrubs (16 species), climbers (eight species), bamboos (four species), sedges (two species), grass (one species) and liana (one species) (Fig. 5). Therefore 39% of the total species of wild edibles were herbs, followed by trees (31%), shrubs (15%), climbers (7%), bamboos (4%), sedges (2%), grass (1%) and liana (1%).

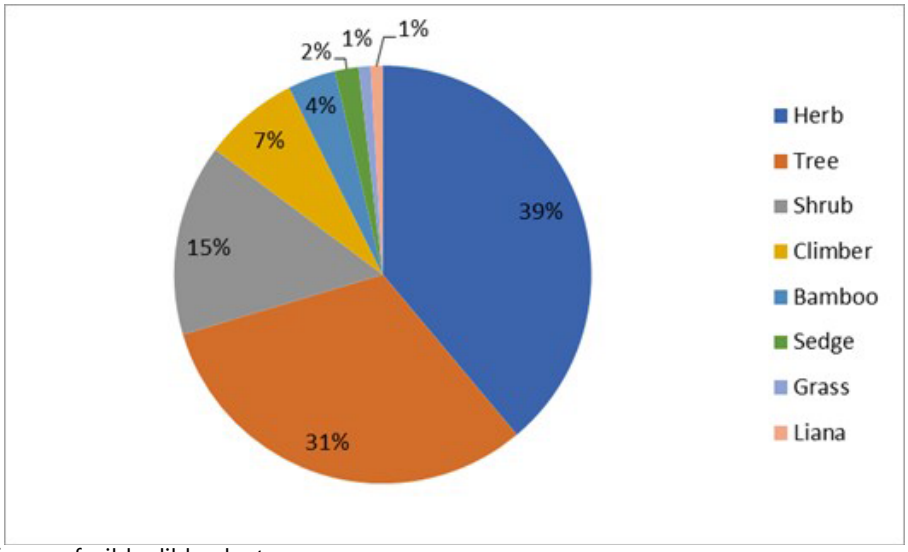

Figure 5. Life forms of wild edible plants

IUCN Red List Categories

According to IUCN Red List Categories, 38 species are categorized as Least Concern (LC), two species as Data Deficient (DD), and 68 species belong to the Not Evaluated (NE) category. This list indicates that out of 108 species, there was no information available on the status of 70 species. The current status of these species needs to be evaluated and appropriate conservation techniques can be applied.

Flowering and Fruiting Phenology

We noted the flowering and fruiting phenology of the wild edible species during the field survey. There was a minimum of one or two species flowering and fruiting in various months. Nine species had flowers and fruits the whole year-round, followed by six species each that flowered and fruited in July-December, March-September, March-October, May-October, and May-November (Table 1). The unknown category (five species) included those species that did not bear flowers or fruits during the study period (Fig. 6). The flowering and fruiting phenology gave vital information on the seasonal availability of WEPs (Feyssa *et al.* 2011). The fruits were the major plant part consumed by the forest dwellers in the study area (Fig. 7). Therefore, the availability of fruiting species all year round was very beneficial for the dwellers of the sanctuary. Flowering and fruiting occurred in different species at different times of the year. Availability of food plants all around the season can be important in predicting species relevance for medicinal and food purposes (Gomes *et al.* 2020, Caetano *et al.* 2020). There was a continuous availability of food resources for the forest dwellers the year round, thus providing them with food, medicine, and cash income even during lean seasons when farming was not practiced.

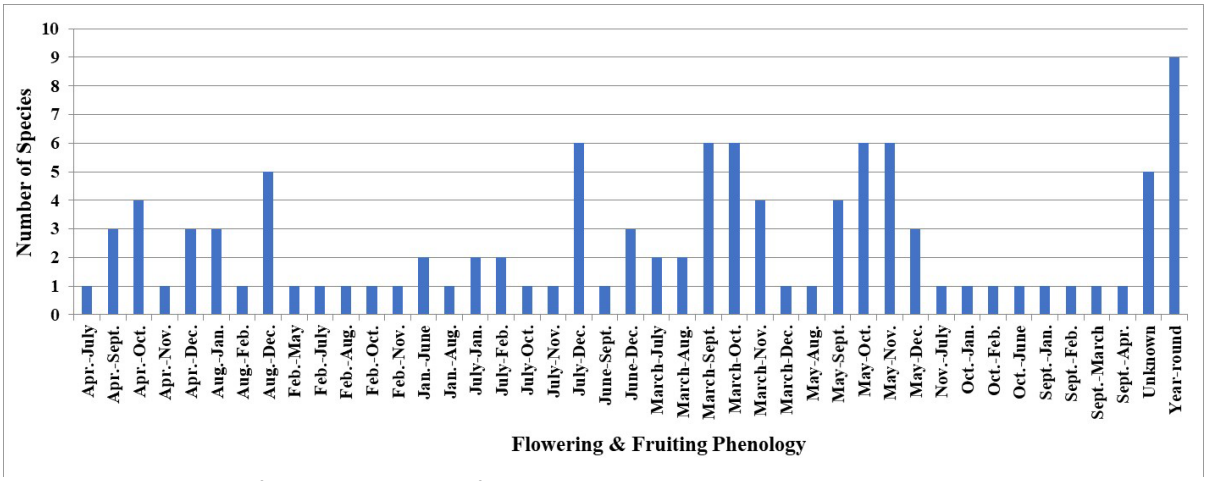

Figure 6. Flowering and fruiting phenology of wild edible plants

Plant parts used

Fruit (46 species) was one of the most dominant edible parts used by the forest dwellers, followed by young shoot (43 species), leaf (35 species), flower, underground part with thirteen (13) species each, whole plant (seven species), stem (six species) and bark (one species) (Fig. 7). Arora (1997) also reported the predominance of fruits as preferred edibles. On the contrary, leaves were the most edible part among the WEPs used by the Zou tribe of Manipur (Gangte *et al.* 2013).

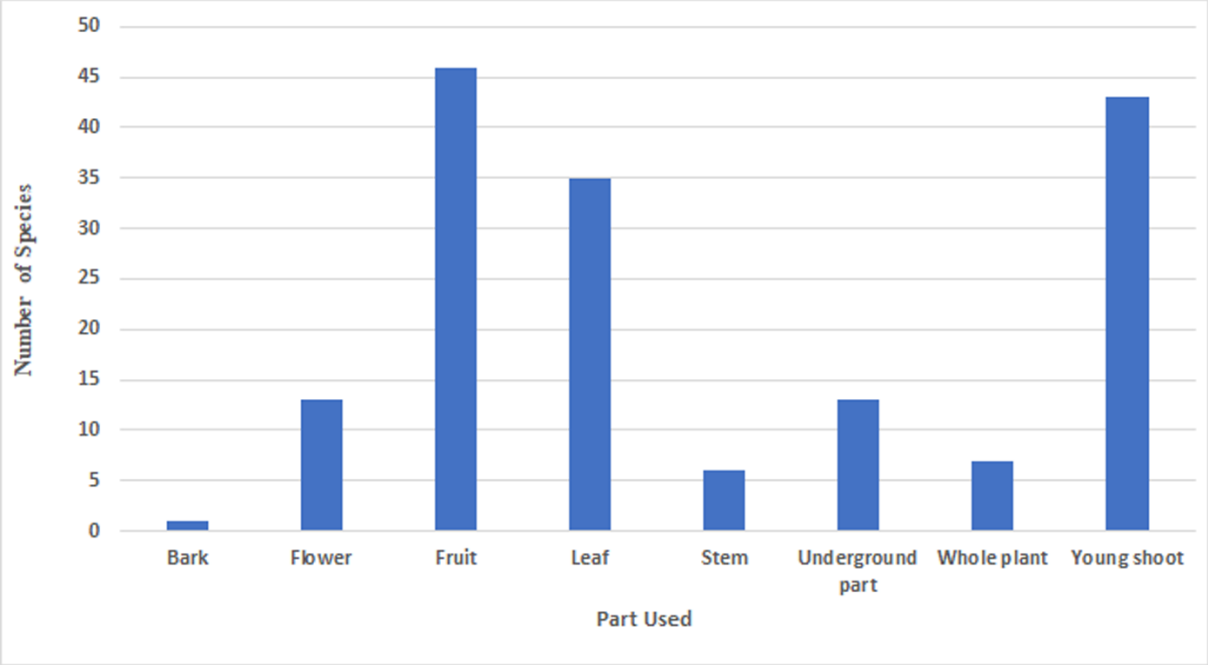

Figure 7. Analysis of plant parts used in wild edible plants

Mode of consumption

Among the recorded edible plants, 49 species (45%) were cooked before consumption, 40 species (37%) were eaten both raw and cooked, and 19 species (18%) were consumed raw (Fig. 8).

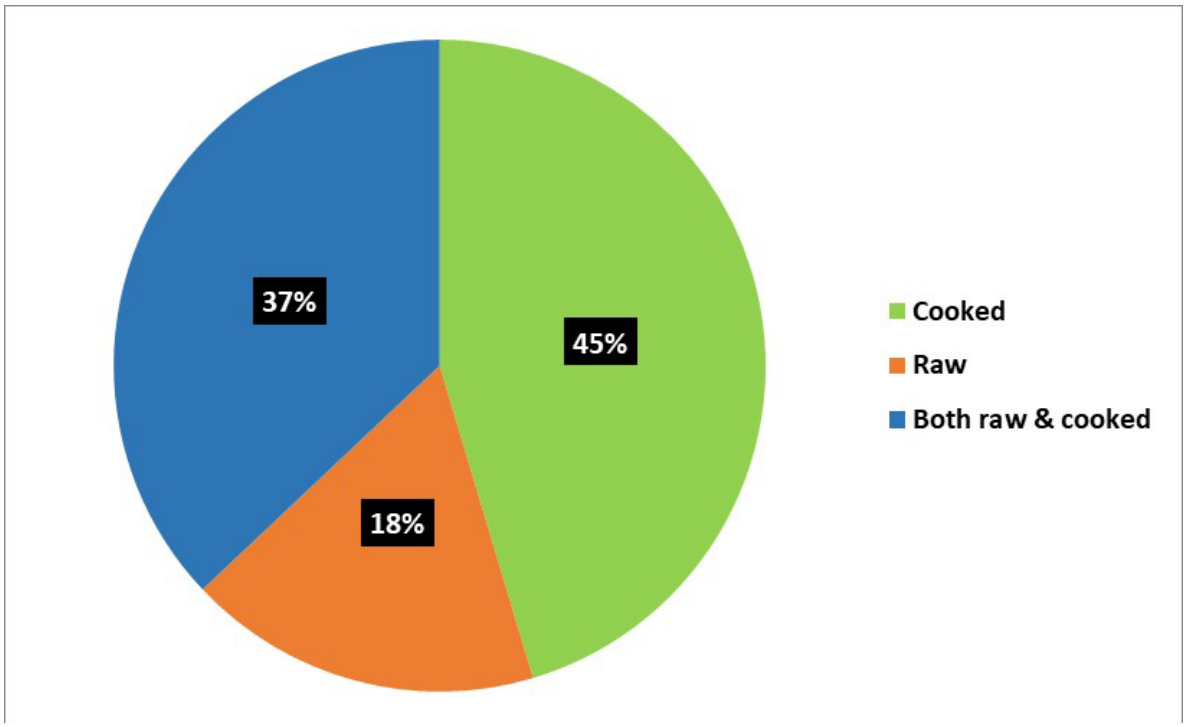

Figure 8. Mode of consumption of wild edible plants

Market analysis

Among the recorded plants, 66 species (61%) were sold in local markets, while 42 species (39%) were not marketed (Fig. 9). Similar results were mentioned by Khan *et al.* (2015), who observed that out of 52 WEP species reported, 36 (i.e., 69%) were being marketed in Senapati District, Manipur.

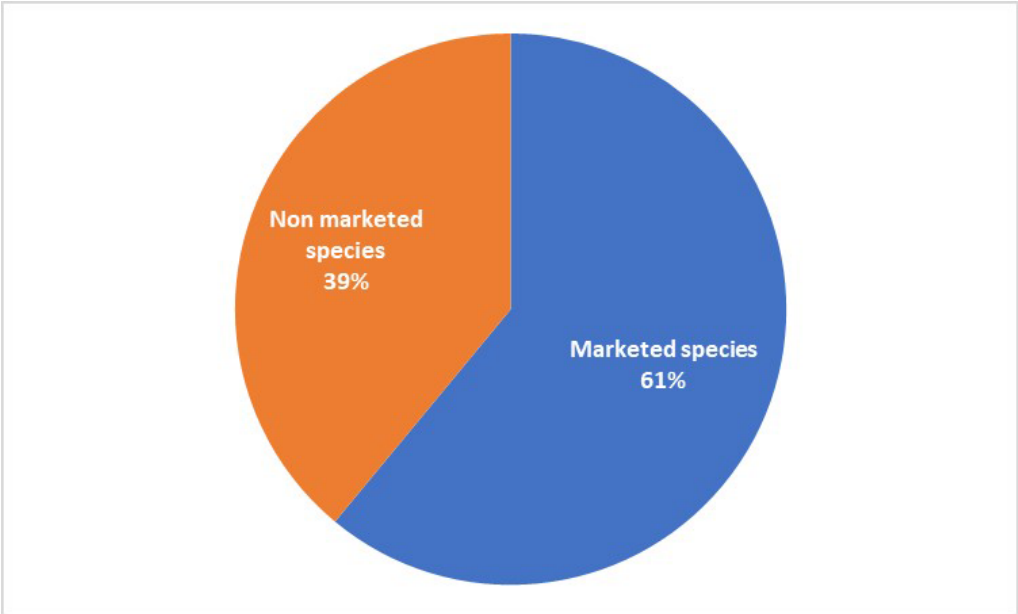

Figure 9. Market availability status of wild edible plants

The average market price (INR and USD) of the marketed species are provided in Table 1. The average price ranged between INR 50-100/kg (USD 0.67-1.34). Some species fetched a relatively higher price. For instance, the tubers of *Asparagus racemosus* were the highest priced. These tubers fetched a price of INR 180-220/kg (USD 2.41-2.95). Also, the bark of *Cinnamomum verum* (INR 150-200/kg; USD 2.01-2.68) and inflorescence of *Wendlandia glabrata* (INR 120-150/kg; USD 1.61-2.01) were highly-priced. These species could be conserved and propagated for the economic upliftment of the forest dwellers.

Some of the WEPs like *Acacia pennata, Alisma plantago-aquatica, Alpinia nigra, Alpinia galanga, Antidesma acidum, Asparagus racemosus, Centella asiatica, Chimonobambusa callosa, Cinnamomum verum, Docynia indica, Leucaena leucocephala, Litsea cubeba, Lysimachia candida, Myrica esculenta, Oenanthe javanica, Rotheca serrata, Wendlandia glabrata, Zanthoxylum acanthopodium*, and *Zanthoxylum armatum* were found to be in high demand and sold at a high price in the local markets. Devi and De (2019) have also reported the high demand for *Acacia pennata, Antidesma acidum, Centella asiatica*, and *Zanthoxylum acanthopodium* in the Imphal East district of Manipur.

On perusal of available literature, we found that the edible use of *Ensete glaucum* recorded in the present study is a new report for Manipur. The fruits are not edible as they contain many seeds. The local people of this region consumed the pseudostem of the wild banana as a vegetable. The pseudostem was also reported to be consumed as a vegetable in Meghalaya (Rao & Hajra 1976) and Tripura (Majumdar *et al.* 2013).

A total of 49 species out of the 108 WEP species have additional value as medicine. They therefore contribute to the value addition of the species in this area. This percentage was high (45.4%) as compared to studies done in Gunung Leuser National Park in Indonesia, where a total of seven plants out of 54 wild edible fruit plants (12.9%) were used for medicinal purposes (Suwardi *et al.* 2020). Some dominant WEPs used as traditional medicine for the treatment of various ailments by the forest dwellers in the study area are: *Acmella paniculata, Alocasia macrorrhizos, Alpinia galanga, Alpinia nigra, Alternanthera sessilis, Antidesma acidum, Artocarpus lacucha, Asparagus racemosus, Clerodendrum glandulosum, Euphorbia hirta, Ficus auriculata*, *Ficus racemosa, Hedychium coronarium*, *Oroxylum indicum, Oxalis corniculata, Phlogacanthus curviflorus, Rhus chinensis, Rotala rotundifolia, Rotheca serrata, Rubus ellipticus, Solanum torvum, Terminalia chebula, Zanthoxylum acanthopodium,* and *Zanthoxylum armatum*.

Discussion

In this study, we have documented 108 WEP species from the study area. Compared to earlier studies (Pfoze *et al.* 2011, Salam *et al.* 2012, Gangte *et al.* 2013, Khan *et al.* 2015, Devi & Salam 2016), the present study reports the highest documented species of WEPs in Manipur.

It was observed that the forest dwellers of YLWLS practiced shifting cultivation. This was the only agricultural practice done by the forest dwellers (Bungnamei & Saikia 2020). Since it was not done the year round, the WEPs that were available all around the year was an important source of income. It has been observed by other workers too that the secondary forests regenerating from long fallows of shifting cultivation are of vital economic importance to local communities, as they are rich in species used by them for food, medicines, and timber (Franco & Mustaqim 2021).

The analysis of the IUCN categories of the WEP in the present study showed most of the species are not evaluated. It is important to ascertain their current status. Even if many of them are commonly found, the various landraces of WEPs having unique climatic and environmental tolerances, might still be threatened. Therefore, future conservation priorities should focus on assessments at the global level, and, for endemics, at the national level (Forest *et al.* 2018; Liu *et al.* 2019).

The present study reveals that Zingiberaceae (seven species) followed by Moraceae, Poaceae, Polygonaceae, and Rubiaceae with five species each, are dominant families of WEPs with the highest number of species (Fig. 2). Zingiberaceae is a significant source of food, medicine, spice, ornamental, and income for the forest dwellers in YLWLS. The family Zingiberaceae, well known for its immense medicinal values, is distributed widely throughout the tropics, particularly in Southeast Asia (Tushar *et al.* 2010). The NE region of India is a zone of greatest concentration where 19 genera and about 88 species of Zingiberaceae are reported (Prakash & Mehrotra 1995), and most of the members are found here at wild state (Tushar *et al.* 2010). Manipur has a rich diversity of ginger flora due to its varied agro-climatic conditions (Sharma *et al.* 2011). In YLWLS, young shoots, flowers, and rhizomes of **pullei** (*Alpinia nigra*) are used to prepare **eromba**. **Eromba** is a traditional dish of Manipur prepared by mashing boiled vegetables, potatoes with chilli, and fermented fish. The rhizomes and young shoots of **loklei** (*Hedychium coronarium*), **takhellei hangampal** (*Hedychium spicatum*), and *Hedychium ellipticum* are used in **eromba**. Flower buds and young shoots of *Amomum dealbatum* and inflorescence of **yaipan** (*Curcuma angustifolia*) are cooked as vegetables. Manipur has a rich diversity of ginger flora due to its varied agro-climatic conditions (Sharma *et al.* 2011). Devi & De (2019) also reported the predominance of wild edible species from the Zingiberaceae family in a study conducted in the Imphal East district of Manipur. Purba & Silalahi (2021) have also reported the use of different species belonging to Zingiberaceae as food plants by the Batak Karo people of North Sumatra, Indonesia.

The next dominant family in the present study was Moraceae. The mode of consumption of some species of Moraceae recorded in the present study is discussed here. Fruits of **heirikokthong** (*Artocarpus lacucha*) and **heiri** (*Ficus semicordata*) are consumed raw or cooked by the forest dwellers. Fruits, leaves, and young shoots of **heibong** (*Ficus auriculata*), **ashi heibong** (*Ficus hispida*), **heibong** (*Ficus racemosa*) are in high demand. In the present study the maximum number of WEP species (four) belonged to the genus *Ficus*. This corroborates the finding of Ulian *et al.* (2020) who mention that *Ficus* is the richest genus in the world with about 100 edible species. Khan *et al.* (2015) also reported Moraceae as the dominant family with the highest number of wild food plants in Kangchup Hills, Senapati, Manipur. Other workers have also documented the ethnobotanical, economic, and medicinal importance of the species belonging to the family Moraceae (Pramanick 2017).

The forest dwellers of the study area use some species of Poaceae as a food resource. Young shoots of **utang** (*Bambusa tulda*), and **watankhoi** (*Dendrocalamus hookeri*) are cooked as **usoi utti** and **usoi kangsu** by the forest dwellers. **Usoi utti** is a traditional dish of Manipur prepared by boiling fresh bamboo shoots with peas, rice, and sodium bicarbonate. **Usoi kangsu** is also a traditional dish of Manipur prepared by mashing boiled and fresh bamboo shoots, peas, chillies, and fermented fish. Young shoots of **laiwa** (*Chimonobambusa callosa*) and **moubi-wa** (*Melocanna baccifera*) are cooked and eaten as **kangsu**. Poaceae is an economically important plant family. Bamboo is one of the most economically important species of the family Poaceae and is also one of the traditional food resources of Manipur (Premlata *et al.* 2020).

Some species of Polygonaceae used by the inhabitants in YLWLS are as follows: Young shoots of **wakha yendem** (*Fagopyrum esculentum*) are cooked as a vegetable with **ngari** (fermented fish) by the forest dwellers. Leaves and young shoots of **yelang** (*Persicaria barbata*), **angom yensil** (*Persicaria chinensis*), and **chaokhong** (*Persicaria hydropiper*) are cooked as vegetables. Leaves and young shoots of **phak-pai** (*Polygonum posumbu*) are eaten with **eromba**. Polygonaceae is an economically important and medicinal family mainly distributed in humid areas of plains and hills of Manipur (Paul & Chowdhury 2019).

The major WEP species of Rubiaceae documented in the present study are discussed here. The inflorescence of **pheija** (*Wendlandia glabrata*) is consumed raw or cooked as a vegetable in **eromba** by the forest dwellers. The young shoots of **langban koukha** (*Hedyotis auriculata*) are eaten raw or cooked. The leaves and ripe fruits of **heibi** (*Meyna spinosa*) are eaten raw. The leaves of *M. spinosa* are used to prepare **singju**. **Singju** is a traditional salad of Manipur prepared by mixing vegetables with roasted fermented fish, chilli, and salt. The leaves and young shoots of **oinam** (*Paederia foetida*) are eaten during stomach ailments. Plants belonging to the Rubiaceae family have been used in traditional medicine and as ornamentals (Karou *et al.* 2011).

Consumed parts and mode of consumption
The most dominant consumed edible part is fruit (46 species) followed by young shoot (43 species), leaf (35 species), flower, and underground parts with 13 species each (Fig. 7). Most of the fruits of plants are eaten raw. Fruits of **chorphon** (*Elaeocarpus floribundus*) and **heibung** (*Garcinia pedunculata*) are eaten raw or cooked as **hei thongba**. **Hei thongba** is a traditional sweet fruit dish of Manipur prepared with boiled fruits and sugar.

Forty-nine WEP species were cooked before eaten, 40 WEP species as both raw and cooked, and 19 WEP species were consumed raw (Fig. 8).

Food categories
The forest dwellers in the study area use wild edible plants as vegetables, fruits, and spices. Out of 108 WEP species documented, 84 plant species are used as vegetables by the forest dwellers. **Pullei** (*Alpinia nigra*), **chengkruk** (*Amaranthus viridis*), **peruk** (*Centella asiatica*), **yaipan** (*Curcuma angustifolia*), **kengoi** (*Lysimachia candida*), **komprek** (*Oenanthe javanica*), **yelang** (*Persicaria barbata*), and **pheija** (*Wendlandia glabrata*) are used as vegetables. Thirty-three WEP species are used as a source of fruits by the forest dwellers, and five WEP species are used as spices. Gangte *et al.* (2013) found that the Zou tribe of Manipur used 70 WEP species out of 84 species as food. Devi & Salam (2016) reported 45 WEP species, out of which 56 species are used as vegetables by the Monsang Naga tribe of Manipur.

Foods for Medicine
Medicinal foods are often termed as physiological functional foods (Swinbanks *et al.* 1993) or neutraceuticals (Biesalski 2001). Some researchers also name them as folk functional food (Valles *et al.* 2017). Yumnam and Tripathi (2012) recorded 64 plants eaten for medicinal purposes by the Meiteis. The most frequent use of edible plants worldwide is in the form of medicines. Ulian *et al.* (2020) estimated 70% of species are used as medicines. In the present study, a total of 49 species out of the 108 WEP species were consumed for their medicinal values (Table 1). The Meiteis eat raw leaves, inflorescence, and other plant parts with indigenous foods such as, **ametpa**, **eromba** or as an ingredient of **singju**, as they believe eating raw have numerous medicinal benefits (Yumnam & Tripathi 2012). Yumnam and Tripathi (2012) recorded 64 plants eaten for medicinal purposes by the Meiteis. In the present study, a total of 49 species out of the 108 WEP species were consumed for their medicinal values. Amaranthaceae, Lamiaceae, Moraceae, Phyllanthaceae, Rutaceae, and Zingiberaceae with three species each are dominant families with the highest number of species used as both food and medicinal plants. It has been observed that boundary between food and medicine in the study area was not clearly demarcated. Whether an item is consumed as a food, or a medicine depends on both its preparation and use. The overlap and categorisation of plants as food and medicine in a range of contexts has also been highlighted by other workers (Sandhu & Heinrich 2005; Pieroni & Price 2006, Jennings *et al.* 2015, Teixidor-Toneu *et al.* 2021). For instance, **phakchet** (*Alternanthera sessilis),* **chengkruk** (*Amaranthus spinosus*), and **chengkruk** (*Amaranthus viridis*) are the species of Amaranthaceae used for both food and medicine by the forest dwellers. The boiled leaves and shoots of *Alternanthera sessilis* are eaten in treatment of boils, bronchitis, and diabetes. The boiled leaves and shoots of *Amaranthus spinosus* are eaten in treatment of blood pressure, diabetes, and liver problems. The shoots of *Amaranthus viridis* are used in treatment of poisonous bites. **Kuthap** (*Clerodendrum glandulosum),* **mayanglambum** *(Leucas aspera),* and **moirang khanam** *(Rotheca serrata)* are the species of Lamiaceae used as both food and medicine. The flowers, leaves, and shoots of *Clerodendrum glandulosum* are eaten fresh or cooked in treatment of hypertension. The decoction of leaves of *C. glandulosum* is used for piles. The leaves of *C. glandulosum* are used in cough, diabetes, diarrhoea, dysentery, rheumatic pain, and skin diseases. The whole plant of *Leucas aspera* is antiseptic. The flowers and leaves' extract of *L. aspera* mixed with honey is taken in cold, cough, and fever. The leaves of *Rotheca serrata* are used in indigestion and stomach disorder.

Heirikokthong (*Artocarpus lacucha*), **heibong** (*Ficus auriculata*), and **heibong** (*Ficus racemosa*) are the species of Moraceae used as both food and medicine by the forest dwellers. The boiled bark extract of *Artocarpus lacucha* is used in diabetes. The ripe fruits of *A. lacucha* are taken for fever and stomach problems. The bark and fruits of *Ficus auriculata* are used in diabetes, diarrhoea, dysentery, and lung diseases. The bark is also used in insect bites and skin diseases. The fresh leaves and fruits of *Ficus racemosa* are eaten in treatment of dysentery, diabetes, and lung diseases. **Ching Heiyen** *(Antidesma acidum),* **motok hei** *(Baccaurea ramiflora),* and **chakpa-heikru** *(Phyllanthus urinaria)* are the species of Phyllanthaceae used as both food and medicine. The boiled leaves and young shoots of *Antidesma acidum* are eaten in treatment of stomach problems. The extract of boiled leaves of *A. acidum* is used in diabetes. The bark of *Baccaurea ramiflora* is used in treatment of skin diseases. The whole plant of *Phyllanthus urinaria* is used in treatment of boils, leucoderma, and skin diseases.

Mukthrubi (*Zanthoxylum acanthopodium*), **mukthrubi** (*Zanthoxylum armatum*), and **ngang** (*Zanthoxylum rhetsa*) are the species of Rutaceae used as both food and medicine by the forest dwellers. The leaves and seeds of *Zanthoxylum acanthopodium, Zanthoxylum armatum* and *Zanthoxylum rhetsa* are used in the treatment of asthma, cold, cough, and fever. The seed oil of *Z. acanthopodium*, *Z. armatum* and *Z. rhetsa* is used in toothache and rheumatism. **Kanghu** (*Alpinia galanga*), **pullei** (*Alpinia nigra*), and **loklei** (*Hedychium coranium*) are the species of Zingiberaceae used as both food and medicine by the forest dwellers. *Alpinia nigra* is used in the treatment of tonsillitis, hypertension, cough, dysentery, fever, gastric problems, piles, and scabies. The boiled rhizome of *Alpinia nigra* is eaten in the treatment of cough and fever. The rhizome of *Hedychium coronarium* is used in the treatment

of cough, vomiting, and piles. The rhizomes of *Hedychium coronarium* has also been reported to be used in Assam and Arunachal Pradesh as febrifuge, antirheumatic, antihelmintic, tonic and mild tranquilliser (Tushar *et al.* 2010). The rhizome of this species is said to possess antibacterial properties (Aziz *et al.* 2009).

Cultivated wild edible plants

Thirty-four WEP species out of the 108 WEP species were cultivated by forest dwellers. Sundriyal and Sundriyal (2003) have reported that the farmers in Sikkim are also cultivating a few wild edible species owing to their high market demand. Though in small numbers, these species are in the semi-domesticated stage. These plants were grown in home gardens and agricultural fields. Zingiberaceae had the most cultivated WEP species. **Kanghu** (*Alpinia galanga*), **heibung** (*Garcinia pedunculata*), **loklei** (*Hedychium coronarium*), and **mukthrubi** (*Zanthoxylum armatum*) are few highly valued cultivated WEPs. These species are discussed briefly below.

***Alpinia galanga* (L.)Willd.**

Kanghu (*Alpinia galanga*) is used as a food, medicinal and ornamental plant by the forest dwellers in YLWLS. The young shoots, flowers, and rhizomes of *A. galanga* are cooked as vegetables. The extract of the inflorescence is gargled with warm water for the treatment of tonsillitis. The leaves are used as antiseptic and astringent. The boiled extract of the rhizome is prescribed for the treatment of cough, dysentery, fever, intestinal worms, and piles. *A. galanga* is planted as an ornamental plant in home gardens. The young shoots, flowers, and rhizomes of the plant are sold for INR 50-70/kg (USD 0.67-0.94) in the market.

The use of this species has been reported by other workers in Manipur. Sharma *et al.* (2011) reported that the inflorescence of *A. galanga* was consumed and the rhizome was used in the treatment of ailments in various districts of Manipur. The rhizomes of *A. galanga* were also used as spices in the preparation of chutney and meat curry by different communities of Kangchup Hills, Senapati district, Manipur (Khan *et al.* 2015).

***Garcinia pedunculata* Roxb.ex Buch.-Ham.**

The fruits of **heibung** (*Garcinia pedunculata*) are eaten raw or cooked as **hei thongba** (fruit dish). *G. pedunculata* is one of the four fruits that are used to prepare **hei thongba. Hei thongba** is also prepared using the fruits of *Garcinia pedunculata* by the Kom tribe in Manipur (Khatoon *et al.* 2012). The fruits are eaten to cure stomach disorders and jaundice. *G. pedunculata* is planted as an ornamental plant. The fruits of the plant fetched a price of INR 40-70/kg (USD 0.54-0.94) in the market. The fruits were also reported to be used for food, juice, and medicinal purposes in six districts of Assam, Northeast India (Sarma & Devi 2015).

***Hedychium coronarium* J. Koenig**

The rhizomes and young shoots of **loklei** (*Hedychium coronarium*) are added to **eromba**. The rhizome of the plant is also used in cough, vomiting, and piles. *H. coronarium* is cultivated as an ornamental plant in home gardens. Rhizomes and young shoots were sold for INR 50-70/kg (USD 0.67-0.94) in the markets. Thongam *et al.* (2016) also reported this species as one of the most widely used wild edible vegetables in Manipur. Sharma *et al.* (2011) also reported that the leaves of *H. coronarium* were used for the treatment of throat infection and the rhizome is used as a tonic, febrifuge, and rheumatic swelling in different districts of Manipur.

***Zanthoxylum armatum* DC.**

The tender leaves and inflorescence of **mukthrubi** (*Zanthoxylum armatum*) are eaten raw. The leaves of the species are added to a traditional dish called **tharoi thongba**. **Tharoi thongba** is **tharoi** (freshwater snails) curry cooked with **loklei** (*Hedychium coronarium*), potatoes, fermented fish, etc. The dried fruits of **mukthrubi** are used as a spice. The leaves and seeds of *Z. armatum* are used in the treatment of asthma, cough, and fever. The oil extracted from the seeds is used to cure toothache and rheumatism. The fruits and leaves of this plant were sold for INR 100-150/kg (USD 1.34-2.01) in the markets. Brijwal *et al.* (2013) reported that *Z. armatum* has various medicinal properties like antimicrobial, anti-inflammatory, analgesic, insecticidal, and larvicidal properties.

Lesser-known wild edible plants

Out of the 102 neglected and underutilized species (NUS) of plants from different regions of the world listed by Ulian *et al.* (2020), 14 species (13.7%) have been recorded from the study area. Some of these species are: *Amaranthus spinosus*, *Asparagus racemosus*, *Fagopyrum esculentum*, *Garcinia* spp., *Sagittaria sagittifolia*, *Trapa natans*, etc. This reflects the potential of the present study. Further research needs to be carried out for these species. The use of some wild plant species as edible plants such as *Amomum dealbatum, Arisaema tortuosum*, **lamgi kwa** (*Caryota urens*)*, Hedychium ellipticum,* **mayanglambum** (*Leucas aspera*)*,* **chakpa-heikru** (*Phyllanthus urinaria*)*,* **morok poklaobi** (*Physalis minima*), and **usoi** (*Schima wallichii*) is less known in Manipur.

Another significant finding of the present study was the use of *Ensete glaucum* or wild banana as food. The pseudostem of **laphu lembra** (*Ensete glaucum*) is consumed as a vegetable in the study area. This is one of the several wild banana species recorded from Manipur (Singh *et al.* 2000). Komor & Devi (2016) also reported that the pseudostem of young shoots, inflorescence and ripe fruits of *E. glaucum* was eaten as a vegetable in Assam, a neighbouring state of Manipur.

Conclusion

The study documented the wild edibles of Yangoupokpi Lokchao Wildlife Sanctuary, Manipur, India. The forest dwellers of the study area use 108 species of WEPs. The forest dwellers sold 66 WEPs in the local markets for livelihood and additional income. The gathering of wild food plants seems to be a very efficient method of subsistence (Delang 2006). Hence WEPs and their collection not only provides nutritional supplement but also help in poverty alleviation. Therefore, cultivating some wild edibles, especially those having added value as medicinal plants, could be recommended and financially supported by the concerned government departments. Joshi *et al.* (2015) also recommended developing 'conservation through use' approaches and promoting domestication, cultivation, marketing, and consumption of wild edibles that could help to maintain these valuable resources for food and nutrition security. WEPs are available easily, affordable, and nutritious. They are generally known to have high nutritional values, higher fibre and polyphenol contents, and greater antioxidant capacity than the corresponding cultivated species (Pieroni & Quave 2005, Pieroni *et al.* 2008). Many WEPs are associated with the traditional ceremonies of the communities. The forest dwellers have good knowledge about the traditional methods of using these species for various purposes. The use of wild plants as food and medicine needs to be revaluated and documented carefully as they are perceived as healthy and represent the preservation of biodiversity as well as of old traditions and cultural roots (Sansanelli *et al.* 2017). The present study has tried to document the rich traditional knowledge of the forest dwellers in the study area. Our recommendation from the present study is that some species of WEPs need to be conserved and utilized sustainably. Conservation and propagation of these species will help generate additional income for the forest dwellers of the sanctuary and also help in ensuring nutrition security. Management strategies of both *in–situ* and *ex–situ* conservation of the WEPs should be encouraged.

Declarations

List of abbreviations: Wild edible plants=WEPs; Yangoupokpi Lokchao Wildlife Sanctuary=YLWLS
Ethics approval and consent to participate: The necessary permission to conduct this study in YLWLS was granted by the State Forest Department, Manipur. This study was conducted after obtaining the approval of local communities/forest dwellers of YLWLS and vendors of local markets. Prior Informed Consent (PIC) was taken from the respondents before recording the information. All respondents were informed about the aim of this study.
Consent for publication: Not applicable
Availability of data and materials: Plant specimens are housed in ASSAM.
Competing interests: The authors declare that they have no competing interests.
Funding: This study was supported by Botanical Survey of India.
Authors' contributions: AD and AAM conceived and supervised the entire study. LRM carried out the fieldwork for the collection of data and plant specimens for herbarium. LRM and AAM identified the plant samples. All the authors analyzed the data and wrote the manuscript. All authors read, reviewed, and approved the final version of the manuscript.

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Appendix 1

Questionnaire used for interview and discussion in performing ethnobotanical study on the wild edible plants

Part A: General information on the respondents

1. Name of respondent:
2. Ethnicity:
3. Address:

Part B: Ethnobotanical information

1. Name wild edible plants used by you?
2. For what purpose are the wild edible plants used by you?
3. What part(s) of the wild edible plants are used?
4. Are the edible plants used cultivated in gardens or farms or harvested from wild?
5. How are the wild edible plants consumed?
6. Name the food recipes of the wild edible plants consumed in different occasions?
7. Name the ingredients (wild edible plants) used for particular recipe?
8. What is the flowering and fruiting phenology of the wild edible plants?
9. Name the marketed wild edible plants in the market?
10. What is the price of the wild edible plants in the market?
11. What are the wild edible plants with medicinal properties?
12. What plants are used for treatment of particular disease/ailment?
13. What part(s) of the plants are used as medicine?
14. How are the medicinal plants used?