Chapter 3

Investigation and documentation on population structure of wild edible fruit plants of Manipur

3.1 INTRODUCTION

Forests are important terrestrial ecosystems primarily comprised of trees and other woody vegetation. They play a vital role in maintaining the Earth's biodiversity and ecological balance, as well as for delivering essential resources and services to people. They provide habitat for a diverse range of plant and animal species, and they also play a crucial role in maintaining air, water, and soil quality. Additionally, forests have a key role in the provision of human populations with food, medicine, and other resources. Furthermore, they have a huge cultural and spiritual significance for many communities across the world. Forest encompasses approximately one-third of the world's land area is covered by forests, and these ecosystems are vital for maintaining biodiversity and ecological balance. Indigenous and rural communities contribute significantly to the protection of these forests through their customary rights, practices, and traditional knowledge. These communities have gained an in-depth understanding of the forest and have developed sustainable resource management systems that have been passed down through generations [1]. These communities can safeguard and preserve the forest while still sustaining their way of life by using their traditional knowledge. An estimated 300,000 plant species are recognised to be essential to ecosystem function because they provide essential primary production and ecosystem structure [2]. A healthy forest ecosystems are a vital component of nature that provide multifaceted environmental advantages including preventing land degradation and desertification, and reducing the risks of natural disasters such as droughts, floods, and landslides [3]. Despite their importance, forests are threatened by human activities such as deforestation, land conversion, and climate change, which has resulted in a loss in global forest cover and biodiversity. A number of civilizations throughout history, such as Mesopotamia, Crete, Cyprus, Greece, and Venice, were driven into decline as a result of forest destruction, leading to timber shortages, excessive erosion, and soil degradation [4].

Since the early 1980s, a number of strategies have been put into place to conserve tropical forests with the participation of local communities, including community-based forest management, joint forest management, and community-based conservation [5]. Indigenous communities have traditionally lived in and managed forests, developing sustainable resource management systems as community forests, which are owned, managed, and protected by local communities. These approaches are the examples of sustainable resource management systems. As they provide incentives for local communities to manage and protect the forests for their own benefit, these strategies have been proved to effectively safeguard and conserve forests. Additionally, equitable resource distribution and access to the benefits of the forest are promoted via community-based management [3]. However, the success of community forests depends on various factors such as legal recognition, community involvement and empowerment, and the availability of resources and support. Community forests have occasionally proven effective at protecting and conserving forests, improving livelihoods, and preserving cultural values. However, in other instances, outside parties or lack of recognition and resources have hindered community management efforts. Understanding the complex relationship between rural people and forests is crucial for developing effective policies and programs that support sustainable forest management and the well-being of dependent communities [6].

Among the various forest products, wild edible fruits are an important resource. They provide a wide range of nutritional and medicinal benefits and are a vital source of food and income for many communities, especially those living in rural and remote areas [7]. Local communities frequently gather and used wild edible fruits as a source of food, medicine, and income, and these activities are an important component of their traditional livelihoods [8]. In addition, they constitute a significant source of genetic diversity and are essential in maintaining the ecological balance of forests. However, the collection and use of wild edible fruits creates significant conservation issues, as over-exploitation has the potential to deplete resources and have detrimental effects the ecosystem. Therefore, it is important to manage and use these resources in a sustainable manner, by involving local communities in the conservation and management of wild edible fruits. Studying tree species' population structure can reveal important information regarding the abundance of wild fruits trees that are edible, their potential for fruit production, their fruiting phenology, and their spatial distribution. This information can help in planning the collection of wild edible fruits and promoting sustainable harvesting.

Based on the literature reviewed, several studies on fruit diversity in community forests have been carried out. These studies have investigated various aspects of fruit diversity, such as variety and availability of fruit species, their distribution and abundance, and the cultural and ecological importance of fruits to local communities. The research also revealed that local communities had a high level of traditional knowledge about the use of fruits, and these fruits are vital to their livelihoods [9]. Studies on wild edible fruits in different parts of India have shown a rich diversity of fruits that are consumed for their nutritional and medicinal benefits [10–14]. It is important to note that these studies also highlighted the necessity for conservation of wild fruits as over-harvesting and deforestation have affected the availability of wild fruits in some regions of India. Studies have also shown that in order to preserve the survival of wild fruits, it is important to harvest wild fruits sustainably and to protect their natural habitats. Therefore, an effort was made to examine the floristic composition and population structure of trees to investigate the diversity of wild edible fruits in two community forests of Tengnoupal district of Manipur. Additionally, data on the ethnomedicinal and economic values of these fruits were also collected. The findings of these ecological investigations are presented in the current chapter.

3.2 MATERIALS AND METHODS

3.2.1 Study area

The study was conducted in Laiching Minou and Machi forest, a two-community forest namely, of Tengnoupal district of Manipur, India. Manipur is located in temperate and tropical rain forest zone within the 23°47’-25°41’N latitude and 93°61’-94°48’E longitude. It is situated in the north-eastern part of the Indian peninsula and covers an area of 22,327 sq km, which constitutes 0.68% of the geographical area of the country. Manipur is bordered by the states of Nagaland to the north, Mizoram to the south, and Assam to the west, while bordered by Myanmar to the east, and is made up of Indo-Myanmar vegetation [15]. According to indigenous LISS III sensor of IRS Resourcesat-2 satellite data from 2021, the state's forest cover is 16,598 sq km, which is 74.34% of its total geographical area. In terms of forest canopy density classes, the state has 905 sq. km under Very Dense Forest (VDF), 6,228 sq. km under Moderately Dense Forest (MDF) and 9,465 sq. km under Open Forest (OF). Forest Cover in the state has decreased by 249 sq. km as compared to the previous assessment reported in ISFR 2019 [16]. Whereas, the global forest area decreased by 178 million hectares between 1990 and 2020 [17]. Manipur is known for its rich culture, history, and biodiversity, including a wide variety of wild fruits that are traditionally consumed by local communities. Rural people in the state heavily depends on the wild edible fruit plants for food, fibre, fodder, dyes, etc. in their socio-economic lives [18]. In Manipur, there are currently 16 districts that are administrated by the state government and divided into various taluks, blocks, and panchayats for governance and administrative purpose. Each district has its unique culture and history and is home to different religious groups such as Hindus, Muslims, and Christians. The state is also home to various ethnic groups and communities, each of which has its own unique languages, customs, and traditions. These diverse communities coexist and contribute to the rich cultural heritage of the state.

3.2.1.1 Selection of study sites

Selection of study sites was made using the finding of market survey analysis of wild edible fruits. Ten (10) districts of Manipur, including Kakching, Thoubal, Tengnoupal, Chandel, Imphal East, Imphal West, Bishnupur, Churachandpur, Kangpokpi and Senapati, were involved in the survey conducted in 2018. In these districts, twenty-four (24) main markets as shown in Fig. 3.1 were surveyed using semi-structured questionnaire. The aim of the survey was to determine the availability of wild edible fruits, its potential source in local markets and prices of wild edible fruits. Further, to identify the suitable study area for investigating their diversity, ethnomedicinal, and economic values. The results showed Tengnoupal district as a major source of wild edible fruits. It has been informed that most of the wild edible fruits found in the nearby city markets were collected mainly from Machi and Laiching Minou and nearby villages in Tengnoupal district. Additionally, vendors also provided additional information on availability, sources, usage, and health benefits of wild edible fruits. Therefore, Laiching Minou and Machi's community conserved forest of Tengnoupal district was selected for the purpose of study.

3.2.1.2 General description of the study sites

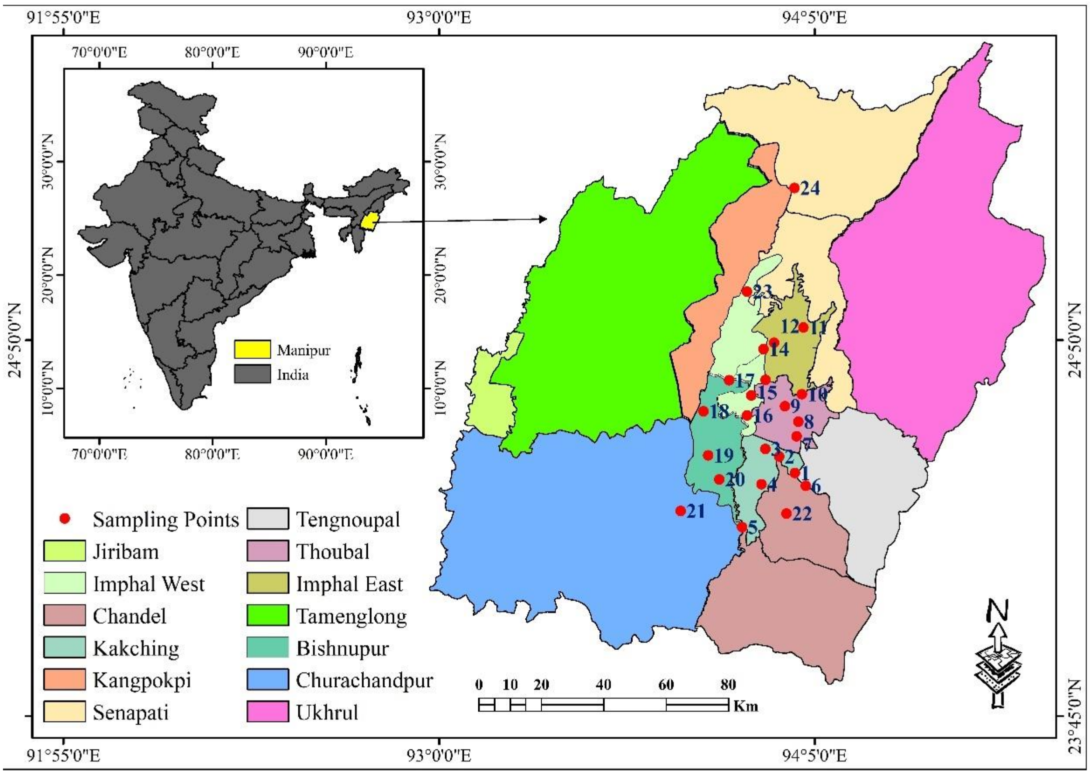
Machi and Laiching Minou villages, which is approximately 14 km apart, are located in the Machi Tehsil of Tengnoupal district of Manipur, India (Fig. 3 2). The villages are surrounded by Tengnoupal Tehsil to the south, Kasom Khullen Tehsil to the north, and Kakching Tehsil to the west. Cities nearby include Kakching, Thoubal, Wangjing, and Pallel.

The Machi village is located at a higher altitude with coordinates N24°30'30.80" and E094°08'29.96" at an elevation of 1443 meters above sea level. It is 48.8 km north of

Tengnoupal, the district headquarters, and is associated to a community forest that covers approximately 205 hectares. According to the 2011 census, the village has a total population of 1,403 people, with 713 males and 690 females. The literacy rate is 60.73%, with 65.64% of males and 55.65% of females being literate. There are a total of 282 houses in the village [19].

On the other hand, the Laiching Minou village is located at N24°30'28.14" and E094°02'18.81" at an elevation of around 1021 meters. It has a community forest of nearly 121 hectares. The village is 27.4 km north of the district headquarters Tengnoupal and 14km from the sub-district headquarters Machi. The village has a total population of 877 people, with 445 males and 432 females. The literacy rate is 46.52%, with 54.38% of males and 38.43% of females being literate. There are approximately 156 houses in the village [20].

These community forests are protected by the Maring Naga tribe. They conserved forest as a community forest to meet their livelihoods requirements. The main occupation of the Maring Naga tribe is cultivation and bamboo crafting.



Sampling points: 1. Pallel Bazar; 2. Kakching Bazar; 3. Wabagai bazar; 4. Waikhong Bazar; 5. Sugnu Bazar; 6. Bungyang Bazar; 7. Khongjom Bazar; 8. Wangjing Bazar; 9. Thoubal Bazar; 10. Yairipok Bazar; 11. Lamlai Bazar; 12. Khurai Bazar; 13. Lilong Bazar; 14. Khwairamban Bazar; 15. Wangoi Bazar; 16. Mayang Imphal Bazar; 17. Nambal Bazar; 18. Bishenpur Bazar; 19. Moirang Bazar; 20. Kumbi Lamjao Bazar, 21. Nute Market; 22. Zaphou bazar; 23. Kangpokpi Bazar; 24. Senapati Bazar

Fig. 3.1 Map of study area showing sampling points of market survey (generated using ArcGIS).

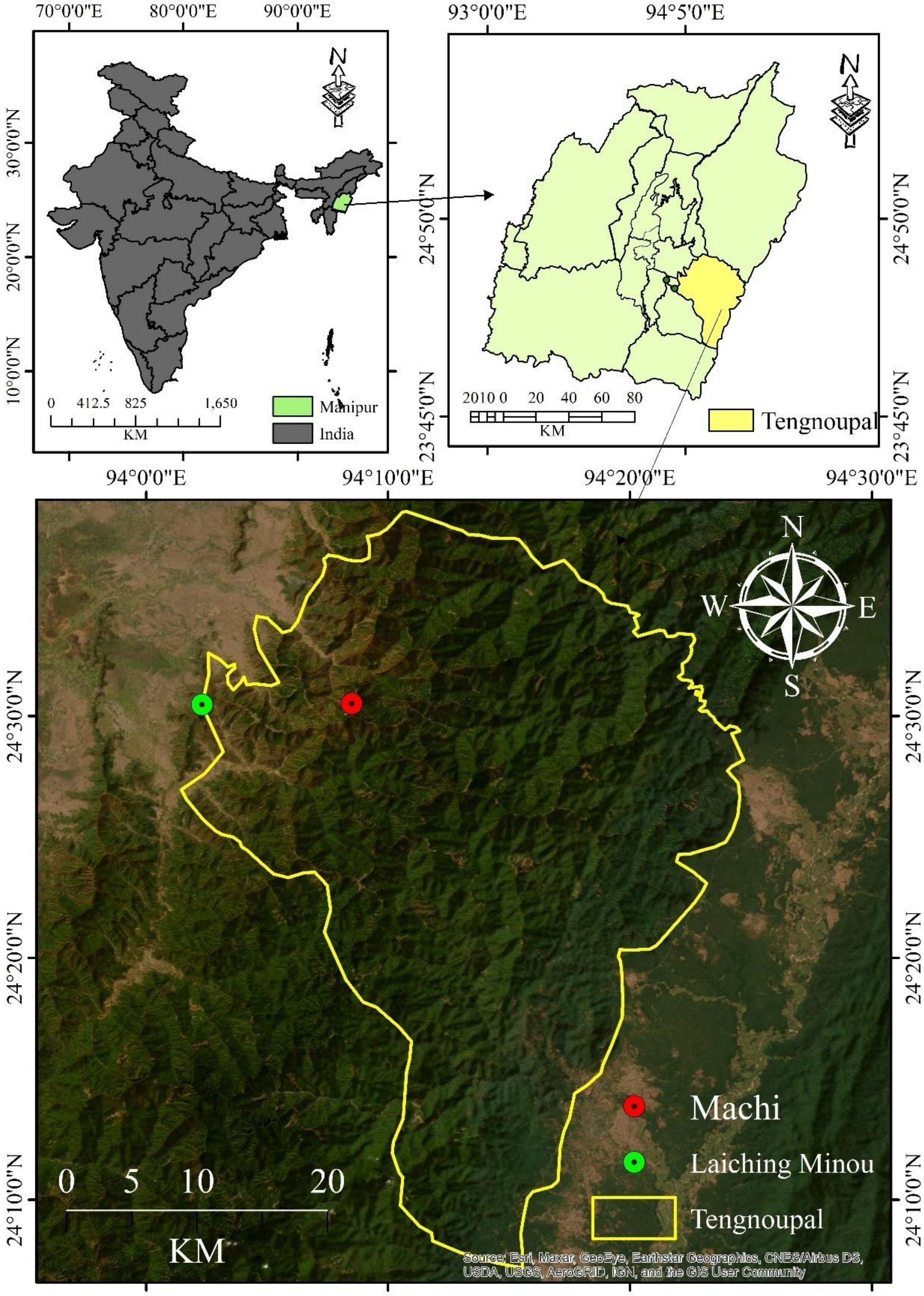


Fig. 3.2 Map of study area showing the two selected villages (generated using Arc GIS).

3.2.2 Tree Diversity documentation

Analysis of tree species diversity in two selected community conserved forests was studied over two years (2018-2019) following random sampling [21]. 50 quadrats of 10m x 10m for trees ≥30 cm girth at breast height (gbh), each covering 0.5 ha in each study site were laid randomly. The gbh was measured at 1.37m height using a measuring tape. Based on the girth classes, the species were further grouped into 10 different categories i.e 30-60 cm, >60-90 cm, >90-120 cm, >120-150 cm, >150-180 cm, >180-210 cm, >210-240 cm, >240-270 cm, >270-300 cm and >300 cm. Identification of tree species was done through personal experience, consulting taxonomists, local floras, and relevant floristic literature such as "Flora of Assam" and "Flora of Manipur" [14,22,23].

For the quantitative analysis, important community parameters such as frequency, density, abundance, and basal area were calculated using the formulae (Eq. 3.1 – 3.4) given by Curtis and McIntosh [24], Philips [21] and Misra [25]. Importance Value Index (IVI) was calculated from relative values of frequency, density, and dominance (Eq. 3.5 -3.8) as per Curtis [26].

$$\text{Frequency} = \frac{\text{Number of quadrats in which the species occurred}}{\text{Total number of quadrats studied}} \times 100 \quad (3.1)$$

$$\text{Density} = \frac{\text{Total number of individuals of each species in all quadrats}}{\text{Total number of quadrats studied}} \times 100 \quad (3.2)$$

$$\text{Abundance} = \frac{\text{Total number of individual species in all quadrats}}{\text{Total number of quadrats in which the species occurred}} \times 100 \quad (3.3)$$

$$\text{Basal area} = \frac{g^2}{4\pi} \times 100 \quad (3.4)$$

where, g = circumference at breast height.

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Total frequency of all the species}} \times 100 \quad (3.5)$$

$$\text{Relative density} = \frac{\text{Density of a species}}{\text{Total density of all the species}} \times 100 \quad (3.6)$$

$$\text{Relative dominance} = \frac{\text{Total basal area of a species}}{\text{Total basal area of all the species}} \times 100 \quad (3.7)$$

$$\text{IVI} = \text{Relative frequency} + \text{Relative density} + \text{Relative dominance} \quad (3.8)$$

For plant species diversity indices, Margalef's species richness index (Eq. 3.9) [27], Shannon-Wiener index of diversity (Eq. 3.10) [28], Simpson's index of dominance (Eq. 3.11) [29], Pielou's evenness index (Eq. 3.12) [30] and Whitford index (Eq. 3.13) [31] was measured. The similarity and dissimilarity of species between the two community forest were calculated as per Sorensen, 1948 (Eq. 3.14 – 3.15) [32] as follows:

Margalef's species richness index (SR)

$$\text{SR} = \frac{\text{S} - 1}{\ln(\text{n})} \quad (3.9)$$

where S = total number of species in the area sampled and n = total number of individuals observed

Shannon-Wiener diversity index (H′)

$$\text{H}' = \sum_{i=1} \text{p}_i \ln(\text{p}_i) \quad (3.10)$$

where, p_i represents the proportional abundance of the i^{th} species in the community.

Simpson's index of dominance (C_D)

$$\text{C}_D = -\sum_{i=1}^{S} (\text{p}_i)^2 \quad (3.11)$$

where, p_i is the same as for the Shannon-Wiener diversity index.

Pielou's Evenness index (e)

$$e = \frac{H'}{\log S} \tag{3.12}$$

where, H′ is the number derived from the Shannon-diversity Index and S is the total number of species.

Whitford index (WI)

$$WI = \frac{\text{Abundance}}{\text{Frequency}} \tag{3.13}$$

According to Curtis and Cottam, (1950) [33], the ratio <0.025 would indicate regular distribution; between 0.025 and 0.05 indicate random distribution and >0.05 contagious distribution.

Index of similarity (S)

$$SR = \frac{S-1}{\ln(n)} \tag{3.9}$$

Where, A = Number of species in the community A (Laiching Minou), B = Number of species in the community B (Machi), and C = Number of common species in both the communities.

Index of dissimilarity (D)

$$D = 1 - S \tag{3.15}$$

For determining the relationship between density, frequency, basal area and diversity (Shannon-Wiener index, H' and Simpson's dominance index, C_D) for tree species, correlation analysis was performed using SPSS.

3.2.2.1 Ethnomedicinal work

To gain insight into the health benefits and ailments inherited from ancestors, a list of fruit species having significant ethnomedicinal importance was compiled based upon the finding of vegetation analysis in the study areas. Data on ethnomedicinal values of the wild edible fruits (trees) were collected using semi-structured questionnaires including personal interaction, audio recording, note-taking, and participant observation focusing on their vernacular name (s), part used, fruiting season, mode of consumption and information based on treating ailments. In the Minou, only one traditional herbal healer was identified through a while there was no traditional herbal healer in Machi community forest areas. Village elders, foresters and vendors are the informants of the study, and they provided information on the uses of wild edible fruits, and traditional herbal healer provides data for treating common health ailments. Scientific nomenclature of recorded plant species was documented according to POWO (Plants of the World Online) [34]. The plant specimens were collected following the standard methods by Jain and Rao, 1977 [35] and voucher samples were prepared as herbarium specimens, housed in the Tezpur University Herbarium House, Department of Environmental Science, Tezpur University, Assam, India.

3.3 RESULTS

3.3.1 Tree composition and community quantitative parameters

To ascertain the adequacy of the sampling effort conducted in both community forests, species accumulation curve was plotted. The studied displayed an asymptotic curve in the species accumulation plot (Fig. 3.3), indicating that the sampling effort was adequate to estimate the species richness in the study sites.

In both the study sites, Minou community forest and Machi community forest a total 124 species were recorded, of which 77 were identified (61 genera under 38 families) and 47 were yet to identified. 28 species belonging to 26 genera under 17 families were found commonly in both the forests. Among the 77 identified tree species, fruits of the 31 tree species are edible representing 26 genera across 21 families.

In the Minou community forest, 83 tree species were documented of which 74 were identified and 9 species are yet to identified. The identified tree species were under 58 genera across 35 families exhibiting high taxonomic diversity. Table 3.1 present the quantitative data for both recorded identified and unidentified tree species in Minou community forest. On the other hand, in the Machi community forest recorded 69 tree species. Out of which 31 species were identified belonging to 29 genera across 21 families and the remaining 38 were reported only in vernacular (Maring) name as these species required further examination to confirm at their species level. The quantitative parameters of tree species recorded in Machi community forest are given in Table 3.2.

From the documented tree species (gbh ≥ 30 cm), Minou community forest exhibited higher density having1084 individuals ha^{-1} while Machi community forest recorded 522 individuals ha^{-1} Table 3.3. *Quercus serratus* L. (130 ha^{-1}) showed the highest density followed by *Castanopsis indica* Roxb. ex Lindl. (72 ha^{-1}) and *Pinus khasya* Royle and *Schima wallichii* (DC.) Korth. with 64 ha^{-1} each in Minou community forest. While, in Machi community forest *Cinnamomum verum* J. S. Presl. had the maximum density with 34 ha^{-1} followed by *Juglan nigra* L. (30 ha^{-1}), *Eleaocarpus sps.* (28 ha^{-1}) and *Pyrus pashia* Buch.-Ham. ex D.Don. (26 ha^{-1}). In regards to basal area, Minou community forest exhibited higher basal area having 78.89 m^{2}ha^{-1} while Machi community forest recorded 68.96 m^{2}ha^{-1}. *Ficus religiosa* L. recorded the highest basal area in Minou community forest with 15.77 m^{2}ha^{-1} and in Machi community forest *Juglans nigra* L. recorded highest basal area having 22.88 m^{2}ha^{-1}.

In Minou community forest, the Importance Value Index (IVI) analysis revealed that *Quercus serratus* L. was the most dominant species with an IVI of 22.57, followed by *Ficus religiosa* L. (IVI=21.27), *Pinus khasya* Royle (IVI=14.98), *Schima wallichii* (DC.) Korth. (IVI=14.61), and *Castanopsis indica* Roxb. ex Lindl. (IVI=14.01). Conversely, in Machi community forest, *Juglans nigra* L. was the most dominant species with an IVI of 44.95, followed by *Cinnamomum verum* J. S. Presl. (IVI=15.08), *Melanorrhoea usitata* Wall. (IVI=11.66), *Pyrus pashia* Buch.-Ham. ex D.Don. (IVI=11.52), and *Schima wallichii* (DC.) Korth. (IVI=10.16).

According to the Importance Value Index (IVI), the dominance distribution curve of trees in community forests exhibits a log-series distribution, with a reverse J-shaped curve indicating a large number of species with low dominance (Fig. 3.4). In Minou community forest, 81% of tree species recorded IVI value having less than 5, 12% of tree species recorded an IVI value within 5-10, and 7% of species had higher IVI values greater than 10. Similarly, in Machi community forest, 71% of tree species recorded an IVI of less than 5, 20% of tree species recorded an IVI within 5-10, and 9% of species had an IVI value greater than 10.

According to the girth-based classification, species having girth size within 30-60 cm record the highest number of individuals while within >270-300 cm had the lowest number of individuals per hectare in both the community forest (Fig.3.5).

Table 3.1 Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area m^2 ha^{-1}, IVI- Importance Value Index) of tree species recorded in Minou community forest.

Sl. No.	Name of the species (Family)	Vernacular name (Manipuri/Maring)	Common name	F	A	D	BA	IVI
1	*Acacia sps*. (Fabaceae)	Mohong		4	2.00	4	1.28	2.49
2	*Alnus nepalensis* D. Don. (Betulaceae)	Pareng/	Nepalese alder	20	2.40	24	1.23	6.21
3	*Annona reticulata* L. (Annonaceae)	Sitaphal/Mangkrak-hei	Red castard apple	2	2.00	2	0.02	0.45
4	*Antidesma bunius* L. (Phyllantheceae)	Heiyen/Theikron	Big nay	2	2.00	2	0.03	0.47
5	*Ardisia coloraba* Roxb. (Primulaceae)	Uthum/Antuntrok	Marlberry	10	2.00	10	0.17	2.36
6	*Arthocarpus integrifolia* Linn. F. (Moraceae)	Theibong/	Jack fruit	6	2.00	6	0.16	1.49
7	*Arthocarpus lakoocha* Roxb. (Moraceae)	Heiru-kothong/Mu-hei	Lakoocha/Monkey Jack	8	2.00	8	0.82	2.76
8	*Averrhoa carambola* L. (Oxalidaceae)	Heinoujom/	Starfruit	4	2.00	4	0.12	1.01
9	*Azadirachta indica* A. Juss. (Meliaceae)	Neem/	Neem	6	2.00	6	0.11	1.42
10	*Bauhinia purpurea* L. (Fabaceae)	Chingthrao/	Bauhinia	14	2.00	14	1.59	5.02
11	*Bischofolia javanica* Blume (Phyllantheceae)	Uthum-Naraobi/Urirom	Bishop wood	8	2.00	8	0.12	1.86
12	*Bombax ceiba* L. (Malvaceae)	Tera/	Cotton tree	10	2.40	12	0.48	2.94
13	*Castanopsis hystrix* J. D. Hooker & Thomson ex A. de Candolle (Fagaceae)	Uthangjing	Chestnut	18	2.44	22	0.76	5.20
14	*Castanopsis indica* Roxb. ex Lindl. (Fagaceae)	Sahi/Shingsha-hing	Indian Chestnut	34	4.24	72	2.53	14.01
15	*Castanopsis sps.* (Fagaceae)	Sahi-napakpi/Chiko-hing	Indian Chestnut	4	3.00	6	0.21	1.30

Table 3.1 (Contd.) Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area m² ha^{-1}, IVI- Importance Value Index) of tree species recorded in Minou community forest.

Sl. No.	Name of the species (Family)	Vernacular name (Manipuri/Maring)	Common name	F	A	D	BA	IVI
16	*Cedrela toona* Roxb. ex Rottler & Willd. (Meliaceae)	Tairel/Kanther	Indian cedar	22	2.00	22	6.18	12.55
17	*Celtis australis* L. (Ulmaceae)	Heikreng/	Hackberry	4	2.00	4	0.26	1.19
18	*Chukrasia tabularis* A. Juss. (Meliaceae)	Tairel-manbi/Ram Kantrei		4	2.00	4	0.28	1.22
19	*Cinnamomum camphora* L. (Lauraceae)	Leina/Khri-hing	Camphor tree	14	2.29	16	0.63	3.99
20	*Cinnamomum verum* J. S. Presl (Lauraceae)	Ushingcha/Shailungkho r	Cinnamon	14	3.71	26	0.62	4.89
21	*Cinnamomun tamala* Buch.-Ham. (Lauraceae)	Tejpata/	Tejpata	6	2.00	6	0.07	1.38
22	*Citrus maxima* Merr. *(*Rutaceae)	Nobab/Hashi-hei	Pomelo	4	2.00	4	0.19	1.10
23	*Dalbergia stipulacea* Roxb. (Fabaceae)	Balibagan/Kaiko	East Himalayan Dalbergia	8	2.50	10	0.21	2.16
24	*Dillenia indica* L. (Dilleniaceae)	Heigree	Elephant apple	2	2.00	2	0.03	0.47
25	*Ehretia acuminata* (DC.) R. Br. (Boraginaceae)	Lamuk/Mukbohing	Koda tree	4	2.00	4	0.05	0.92
26	*Elaeagnus conferta* Roxb. (Elaeagnaceae)	Heiyai/Parwa-hei	Wild Olive	2	2.00	2	0.08	0.53
27	*Eleaocarpus florobundus* Bl.(Elaeocarpaceae)	Chorphon/	Indian Olive	6	2.00	6	0.09	1.40
28	*Eleaocarpus sps.* (Elaeocarpaceae)	Heironkha/Krun-hei		2	2.00	2	0.02	0.46
29	*Erythrina suberosa* Roxb. (Fabaceae)	Kurao/Kanto-hing	Coral tree	8	2.00	8	1.44	3.54

Table 3.1 (Contd.) Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area m² ha^{-1}, IVI- Importance Value Index) of tree species recorded in Minou community forest.

Sl. No.	Name of the species (Family)	Vernacular name (Manipuri/Maring)	Common name	F	A	D	BA	IVI
30	*Erythrina variegata* L. (Fabaceae)	Kurao-angouba/Kanto-hing	Coral tree	6	2.00	6	0.23	1.58
31	*Eucalyptus spp.* (Myrtaceae)	Nasik	Eucalyptus	2	2.00	2	0.06	0.51
32	*Eugenia jambolana* Lam. (Myrtaceae)	Wild-Jamun/Rumrei-hing,Muiril	Jambul	6	2.00	6	0.09	1.41
33	*Eugenia precox* Roxb. (Myrtaceae)	Silheima/Silheibi	Stopper	6	2.00	6	0.24	1.60
34	*Ficus auriculata* Lour. (Moraceae)	HeibonTeipung	Fig tree	10	2.40	12	0.44	2.89
35	*Ficus benghalensis* L. (Moraceae)	Khongnang/Rahui	Banyan	2	2.00	2	0.44	0.99
36	*Ficus cunia* Buch.-Ham. ex Roxb. (Moraceae)	Heirit/Chir-hei	Fig tree	16	2.75	22	0.52	4.64
37	*Ficus racemosa* L. (Moraceae)	Ashiheibong,Heipa/Ba-hei	Cluster Fig	6	2.67	8	0.22	1.75
38	*Ficus religiosa* L. (Moraceae)	Sana-Khongnang/Chir-hing	Sacred fig	6	2.00	6	15.77	21.27
39	*Ficus tsjakela* Burm.f (Moraceae)	Tarung-khongnang/Unchi	Karal Fig	4	2.00	4	0.12	1.02
40	*Flaccurtia jangomas* (Lour.) Raeusch. (Salicaceae)	Heitroi/Theikantung	Puneala plum	4	2.00	4	0.05	0.92
41	*Garcinia pedunculata* Roxb. (Clusiaceae)	Heibung/Changnaihei	Purple mangosteen	8	2.00	8	3.23	5.81
42	*Garcinia xanthochymus* Hook.f. (Clusiaceae)	Heirangoi/Theishor-hei	Yellow mangosteen	4	2.00	4	0.09	0.97
43	*Gmelina arborea* Roxb. (Lamiaceae)	Wang/Marhong-hing	Gamhar	24	2.33	28	1.78	7.77

Table 3.1 (Contd.) Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area m² ha^{-1}, IVI- Importance Value Index) of tree species recorded in Minou community forest.

Sl. No.	Name of the species (Family)	Vernacular name (Manipuri/Maring)	Common name	F	A	D	BA	IVI
44	*Grevillea robusta* A. Cunn. ex R. Br. *(*Proteaceae)	Koubilia/	Silky oak	4	4.00	8	2.05	3.83
45	*Jatropha curcas* L. (Euphorbiaceae)	Awakege/Kege	Physic nut	10	2.80	14	0.41	3.04
46	*Machilus villosa* (Roxb.) Hook. fil. (Lauraceae)	Uningthou-manbi/		8	2.00	8	0.40	2.22
47	*Magnilia champaca* L. (Magnoliaceae)	Leihao/	Champaka	8	2.00	8	0.10	1.84
48	*Magnolia griffithii* Hook.f. & Thomson. (Magnoliaceae)	Utham-ban/	Magnolia	6	2.00	6	0.34	1.72
49	*Mangifera indica* L. (Anacardiaceae)	Heinou/Heinou	Mango	14	2.00	14	4.46	8.65
50	*Melanorrhoea usitata* Wall. (Anacardiaceae)	Khe-U/Khring-khang	Burmese lacquer	26	3.54	46	1.18	8.92
51	*Melia azadirachta* L. (Meliaceae)	Seichrak/Shangl-hing	Chinaberry	10	2.00	10	0.20	2.40
52	*Mesua ferrea* L. var. coromandeliana (Wight) N.P. Singh(Calophyllaceae)	Uthou (Nageshwer)/	Indian rose chestnut	8	2.00	8	0.37	2.18
53	*Microcos paniculata* L. (Tiliaceae)	Heitup/Heituk	Wild Apple	8	2.00	8	0.98	2.96
54	*Oroxylum indicum* (L.) Kruz. *(*Bignoniaceae)	Samba/	Sonapatha	10	2.80	14	0.25	2.83
55	*Parkia roxburghii* G.Don (Fabaceae)	Yongchak/Muhong-hing	Tree bean	8	2.00	8	0.16	1.92
56	*Phoebe hainesia* Brandis (Lauraceae)	Uningthou/Bonapakpi	Bonsum	16	2.00	16	1.93	5.88

Table 3.1 (Contd.) Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area m^2 ha^{-1}, IVI- Importance Value Index) of tree species recorded in Minou community forest.

Sl. No.	Name of the species (Family)	Vernacular name (Manipuri/Maring)	Common name	F	A	D	BA	IVI
57	*Phyllanthus emblica* L. (Euphorbiaceae)	Heikru/Puklu	Gooseberry/Amla	18	2.22	20	0.58	4.78
58	*Pinus khasya* Royle (Pinaceae)	Uchan	Pine Tree	34	3.76	64	3.88	14.98
59	*Psidium guajava* L. (Myrtaceae)	Pungdol/Pungdol	Guava	8	2.50	10	0.17	2.11
60	*Pterospermum acerifolium* L. (Malvaceae)	Kwakla/Bunbo	Maple-Leaved Bayur	6	2.00	6	0.11	1.43
61	*Quercus serratus* L. (Fagaceae)	Uyung/Bok-hing	Oak Tree	52	5.00	130	3.33	22.57
62	*Rhus semialata* Murr. (Anacardiaceae)	Heimang/Kongba	Nutgall tree	4	2.00	4	0.04	0.91
63	*Sapindus mukorossi* Gaertn. (Sapindaceae)	Kekru/Lingshi	Soapberries	16	2.00	16	0.44	3.99
64	*Schima wallichii* (DC.) Korth. (Theaceae)	Usoi/Shoumun	Needlewood Tree	44	2.91	64	2.62	14.61
65	*Spondias pinnata* (L.f.) Kurz (Anacardiaceae)	Heining/Tonto	Wild Mango	8	2.00	8	1.37	3.46
66	*Stereospermum chelonoides* (L. fil.) DC. (Bignoniaceae)	Missi/Machi-hing	Padize wood	10	2.40	12	0.83	3.39
67	*Syzgium cumini* L. (Myrtaceae)	Jam/Jamhei	Java Plum	8	2.00	8	0.20	1.97
68	*Tamarindus indica* L. (Fabaceae)	Mangi-hei/	Tamarind	2	2.00	2	0.07	0.51
69	*Tectona grandis* L. f. (Lamiaceae)	Chingshu/	Teak	14	2.57	18	3.07	7.26
70	*Terminalia chebula* Retz. (*Combrataceae)*	Manahei/Chopraheikru	Shilikha	2	2.00	2	0.02	0.46
71	*Terminalia myriocarpa* Van Heurck & Müll.Arg. (Combrataceae)	Tolhao/	East Indian Almond	14	2.00	14	0.61	3.77

Table 3.1 (Contd.) Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area $m^2\ ha^{-1}$, IVI- Importance Value Index) of tree species recorded in Minou community forest.

Sl. No.	Name of the species (Family)	Vernacular name (Manipuri/Maring)	Common name	F	A	D	BA	IVI
72	*Tetrameles nudiflora* r. Br. (Tetramelaceae)	Wang-chok, Maina/Wangthinam	False hamp tree	4	2.00	4	0.27	1.20
73	*Vangueria spinosa* Roxb. ex Link (Rubiaceae)	Heibi/Heipi	Muyna	6	2.00	6	0.07	1.37
74	*Ziziphus mauritiana* Lam. (Rhamnaceae)	Boroi/Boroi	Indian plum	8	2.00	8	0.23	2.01
75	Unidentified species 1	Angke-hing		6	2.67	8	0.37	1.94
76	Unidentified species 2	Khungle-hing		6	2.00	6	0.81	2.31
77	Unidentified species 3	Matou/Chawi		6	2.00	6	0.17	1.51
78	Unidentified species 4	Mlhing-hing		10	2.00	10	0.34	2.58
79	Unidentified species 5	Raitang-hing		18	2.67	24	1.33	6.09
80	Unidentified species 6	Sukril-hing		10	2.80	14	0.64	3.33
81	Unidentified species 7	Tangbo		6	2.67	8	0.26	1.81
82	Unidentified species 8	Thingput-hing		4	3.00	6	0.65	1.87
83	Unidentified species 9	Uyeel/Karangdil		4	2.00	4	0.48	1.47

Table 3.2 Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area m² ha^{-1}, IVI- Importance Value Index) of tree species recorded in Machi community forest.

Sl. No.	Name of the species (Family)	Vernacular name (Manipuri/Maring)	Common name	Family	F	A	D	BA	IVI
1	*Alnus nepalensis D. Don.* (Betulaceae)	Pareng⁄	Nepalese alder	Betulaceae	8	3.00	12	0.72	5.07
2	*Ardisia coloraba* Roxb. (Primulaceae)	Uthum⁄Antuntrok	Marlberry	Primulaceae	4	2.00	4	0.04	1.69
3	*Arthocarpus lakoocha Roxb.* (Moraceae)	Heiru-kothong ⁄Muhei	Lakoocha/Monkey Jack	Moraceae	4	2.00	4	0.07	1.72
4	*Bauhinia purpurea* L. (Fabaceae)	Chingthrao⁄	Bauhinia	Fabaceae	12	2.67	16	2.48	9.25
5	*Castanopsis hystrix* J. D. Hooker & Thomson ex A. de Candolle (Fagaceae)	Uthangjing⁄	Chestnut	Fagaceae	6	2.00	6	0.34	2.94
6	*Castanopsis sps.* (Fagaceae)	Sahi-napakpi⁄Chiko-hing	Indian Chestnut	Fagaceae	10	2.00	10	1.69	6.52
7	*Cedrela toona* Roxb. ex Rottler & Willd. (Meliaceae)	Tairel⁄Kanther	Red Cedar	Meliaceae	6	2.00	6	0.25	2.80
8	*Chukrasia tabularis A. Juss.* (Meliaceae)	Tainirel⁄Shanyang	Chittagong wood	Meliaceae	2	2.00	2	0.08	0.93
9	*Cinnamomum verum* J. S. Presl (Lauraceae)	Ushingcha⁄Shailungkhor	Cinnamon	Lauraceae	28	2.43	34	1.74	15.08
10	*Ehretia acuminata* (DC.) R. Br. (Boraginaceae)	Lamuk⁄Mukbo	Koda tree	Boraginaceae	8	2.00	8	0.91	4.58

Table 3.2 (Contd.) Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area m² ha^{-1}, IVI- Importance Value Index) of tree species recorded in Machi community forest.

Sl. No.	Name of the species (Family)	Vernacular name (Manipuri/Maring)	Common name	Family	F	A	D	BA	IVI
11	*Elaeagnus conferta* Roxb. (Elaeagnaceae)	Heiyai/Parwa	Wild Olive	Elaeagnaceae	4	2.00	4	0.05	1.70
12	*Eleaocarpus sps.* (Elaeagnaceae)	Heironkha/Khrunbal		Eleaocarpaceae	24	2.33	28	2.75	14.52
13	*Eugenia jambolana* Lam. *(Myrtaceae)*	Wild Jamun/Rumrei-hing	Jambul	Myrtaceae	8	2.00	8	1.94	6.07
14	*Ficus cunia Buch.-Ham. ex Roxb.* (Moraceae)	Heirit/Sudhei or Chir-hei	Drooping fig	Moraceae	8	2.00	8	0.62	4.16
15	*Ficus racemosa* L. (Moraceae)	Heipaa/Heibong/Babo	Cluster Fig	Moraceae	8	2.00	8	0.19	3.53
16	*Garcinia xanthochymus* Hook.f. (Meliaceae)	Heirangoi/Theisor-hei	Rohituka tree	Meliaceae	4	2.00	4	0.18	1.89
17	*Juglans nigra* L. (Juglandaceae)	Heijuga/Khaihei	Wallnut	Juglandaceae	28	2.14	30	22.88	44.95
18	*Magnilia champaca* L. (Magnoliaceae)	Leihao/	Champaka	Magnoliaceae	4	2.00	4	0.27	2.01
19	*Melanorrhoea usitata* Wall. (Anacardiaceae)	KheU or Lamkhe/Khring-khang	Burmese lacquer	Anacardiaceae	12	2.33	14	4.41	11.66
20	*Melia azadirachta* L. (Meliaceae)	Seichrak/Shangl-hing	Chinaberry	Meliaceae	6	2.00	6	0.86	3.69

Table 3.2 (Contd.) Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area m² ha^{-1}, IVI- Importance Value Index) of tree species recorded in Machi community forest.

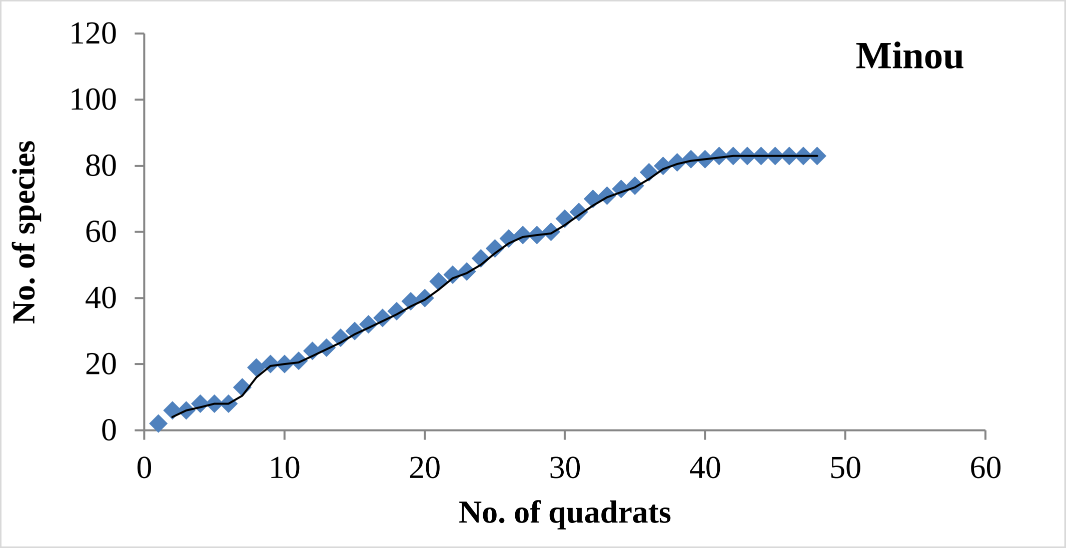
Sl. No.	Name of the species (Family)	Vernacular name (Manipuri/Maring)	Common name	Family	F	A	D	BA	IVI
21	*Microcos paniculata* L. (Tiliaceae)	Heitup/Heituk	Wild Apple	Tiliaceae	12	2.67	16	0.49	6.36
22	*Phoebe hainesiana* Brandis (Lauraceae)	Uningthou/Bulyou	Bonsum	Lauraceae	14	2.00	14	1.24	7.50
23	*Phyllanthus emblica* L. (Euphorbiaceae)	Heikru/Puklu	Gooseberry/Amla	Euphorbiaceae	10	2.40	12	0.43	5.08
24	*Pyrus pashia* Buch.-Ham. ex D.Don. (Rosaceae)	Cherry/Khurshi	Black Cherry	Rosaceae	20	2.60	26	1.54	11.52
26	*Quillaja saponaria* Molina (Quillajaceae)	/Risha-hing	Soap-bark tree	Quillajaceae	8	3.00	12	0.95	5.39
27	*Rhus semialata* Murr. (Anacardiaceae)	Heimang/	Nutgall tree	Anacardiaceae	6	2.00	6	0.18	2.71
28	*Sapindus mukorossi* Gaertn. (Sapindaceae)	Kekru/Lingshi	Soapberries	Sapindaceae	4	2.00	4	0.24	1.98
29	*Schima wallichii* (DC.) Korth. (Theaceae)	Usoi/Shoumun	Needlewood Tree	Theaceae	16	2.25	18	2.25	10.16
30	*Syzgium cumini* L. (Myrtaceae)	Jam/Rimui	Malabar plum	Myrtaceae	4	2.00	4	1.01	3.10
31	*Vangueria spinosa* Roxb. ex Link (Rubiaceae)	Heibi/	Muyna	Rubiaceae	2	2.00	2	0.11	0.97

Table 3.2 (Contd.) Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area m^2 ha^{-1}, IVI- Importance Value Index) of tree species recorded in Machi community forest.

Sl. No.	Name of the species (Family)	Vernacular name (Maring)	F	A	D	BA	IVI
32	Unidentified species 1	Bo-hing	2	2	2	0.94	2.18
33	Unidentified species 2	Borchang	4	2	4	0.03	1.67
34	Unidentified species 3	Borkha	2	2	2	0.11	0.97
35	Unidentified species 4	Chir-hing	4	2	4	0.15	1.85
36	Unidentified species 5	Hingmanthong	2	2	2	0.15	1.03
37	Unidentified species 6	Hingmengcha	4	2	4	0.06	1.71
38	Unidentified species 7	Hing-ngoucha	2	2	2	0.02	0.85
39	Unidentified species 8	Hokshuk-hing	8	2	8	0.43	3.88
40	Unidentified species 9	Kalak-hing	4	2	4	0.3	2.07
41	Unidentified species 10	Khaleng	12	3	18	1.54	8.27
42	Unidentified species 11	Khroukha	2	2	2	0.04	0.88
43	Unidentified species 12	Kok-hei	4	2	4	0.11	1.79
44	Unidentified species 13	Kui-hei	4	3	6	0.25	2.37
45	Unidentified species 14	Kungbo	2	2	2	0.11	0.97
46	Unidentified species 15	Mlhing-hing	2	2	2	0.09	0.95
47	Unidentified species 16	Mong-hing	4	2	4	0.97	3.04
48	Unidentified species 17	Mulchung	2	2	2	0.09	0.95
49	Unidentified species 18	Mun-hing	4	2	4	1.68	4.06
50	Unidentified species 19	Namtaar	2	2	2	0.04	0.87
51	Unidentified species 20	Nasa	4	2	4	0.17	1.87
52	Unidentified species 21	Rampampap	12	2	12	0.81	6.06
53	Unidentified species 22	Riddei	6	2	6	0.06	2.52

Table 3.2 (Contd.) Quantitative data (F- Frequency %, A- Abundance, D- Density ha^{-1}, BA- Basal area $m^2\ ha^{-1}$, IVI- Importance Value Index) of tree species recorded in Machi community forest.

Sl. No.	**Name of the species (Family)**	**Vernacular name (Maring)**	**F**	**A**	**D**	**BA**	**IVI**
54	Unidentified species 23	Rumni-hing	2	2	2	0.44	1.45
55	Unidentified species 24	Rumtui	2	2	2	0.34	1.3
56	Unidentified species 25	Sansun-hing	4	2	4	0.04	1.69
57	Unidentified species 26	Shallhim	6	3.33	10	1.44	5.29
58	Unidentified species 27	Shan-hing	2	2	2	0.36	1.33
59	Unidentified species 28	Shanyang	4	2	4	0.25	2
60	Unidentified species 29	Shimhei	4	3	6	0.65	2.96
61	Unidentified species 30	Sukril-hing	8	2	8	0.71	4.28
62	Unidentified species 31	Theineichak	4	2	4	0.19	1.91
63	Unidentified species 32	Thingjang	2	2	2	0.24	1.16
64	Unidentified species 33	Thingroot	8	2.5	10	1.73	6.15
65	Unidentified species 34	Thingshaingal	2	2	2	0.11	0.97
66	Unidentified species 35	Trao-hing	2	2	2	0.59	1.67
67	Unidentified species 36	Tumpak-hing	2	2	2	0.25	1.17
68	Unidentified species 37	Wadi-hing	8	2	8	0.43	3.88
69	Unidentified species 38	Waopuk-hing	8	2	8	1.26	5.09



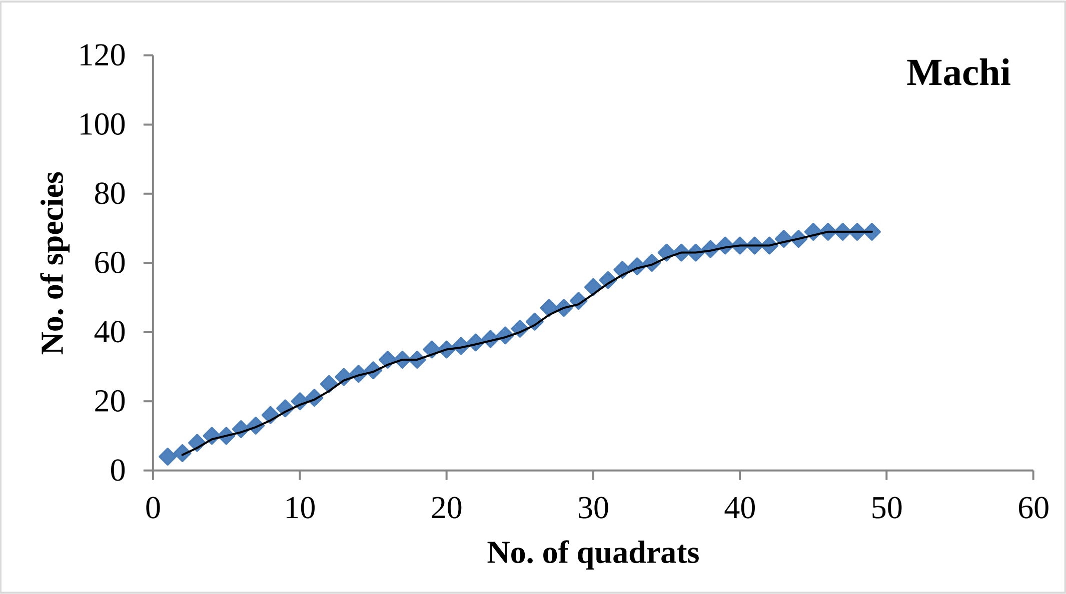


Fig. 3.3 Species accumulation curve of tree species recorded in the two community forest.

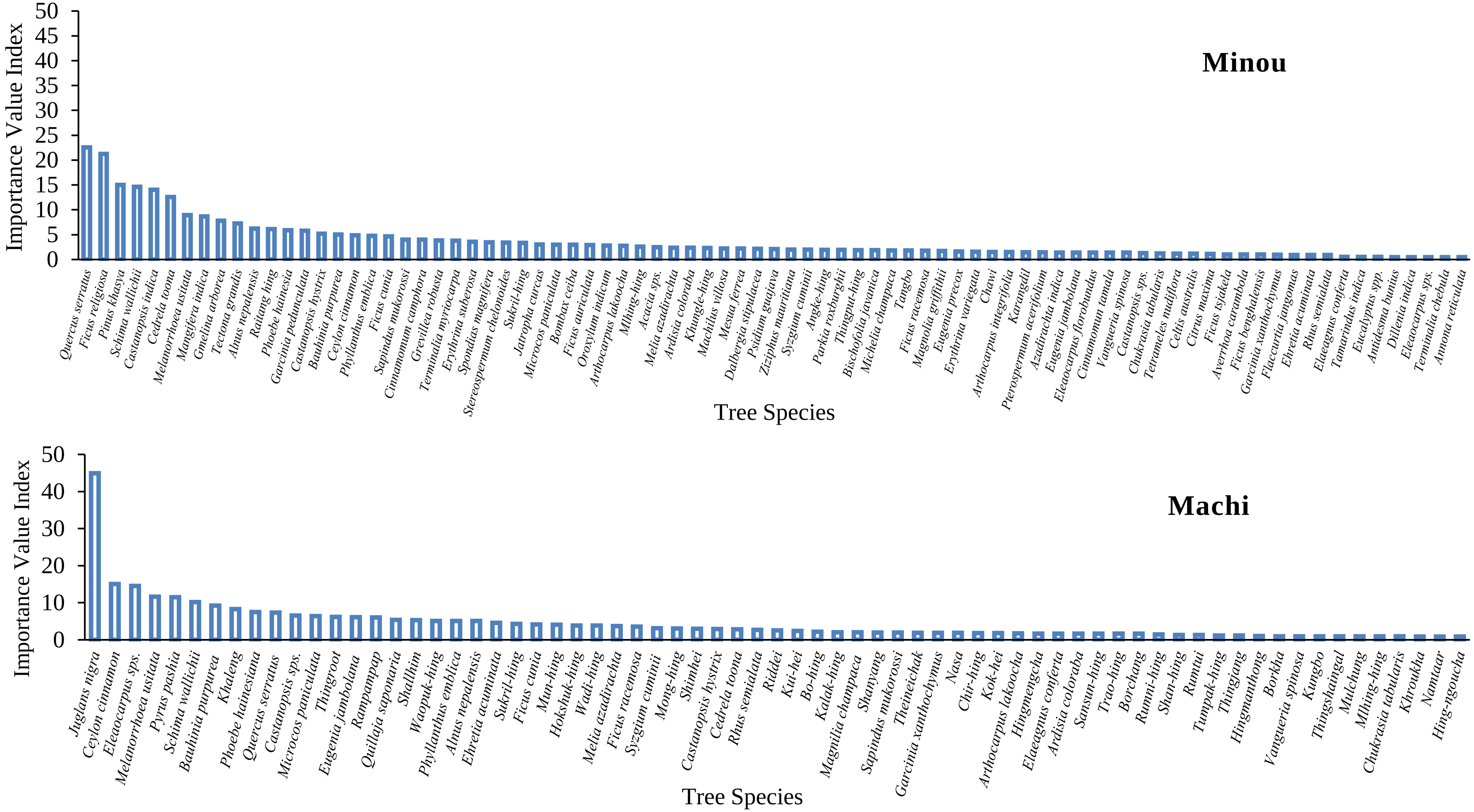


Fig. 3.4 Dominance-distribution curve of tree species of the two-community forests of Manipur

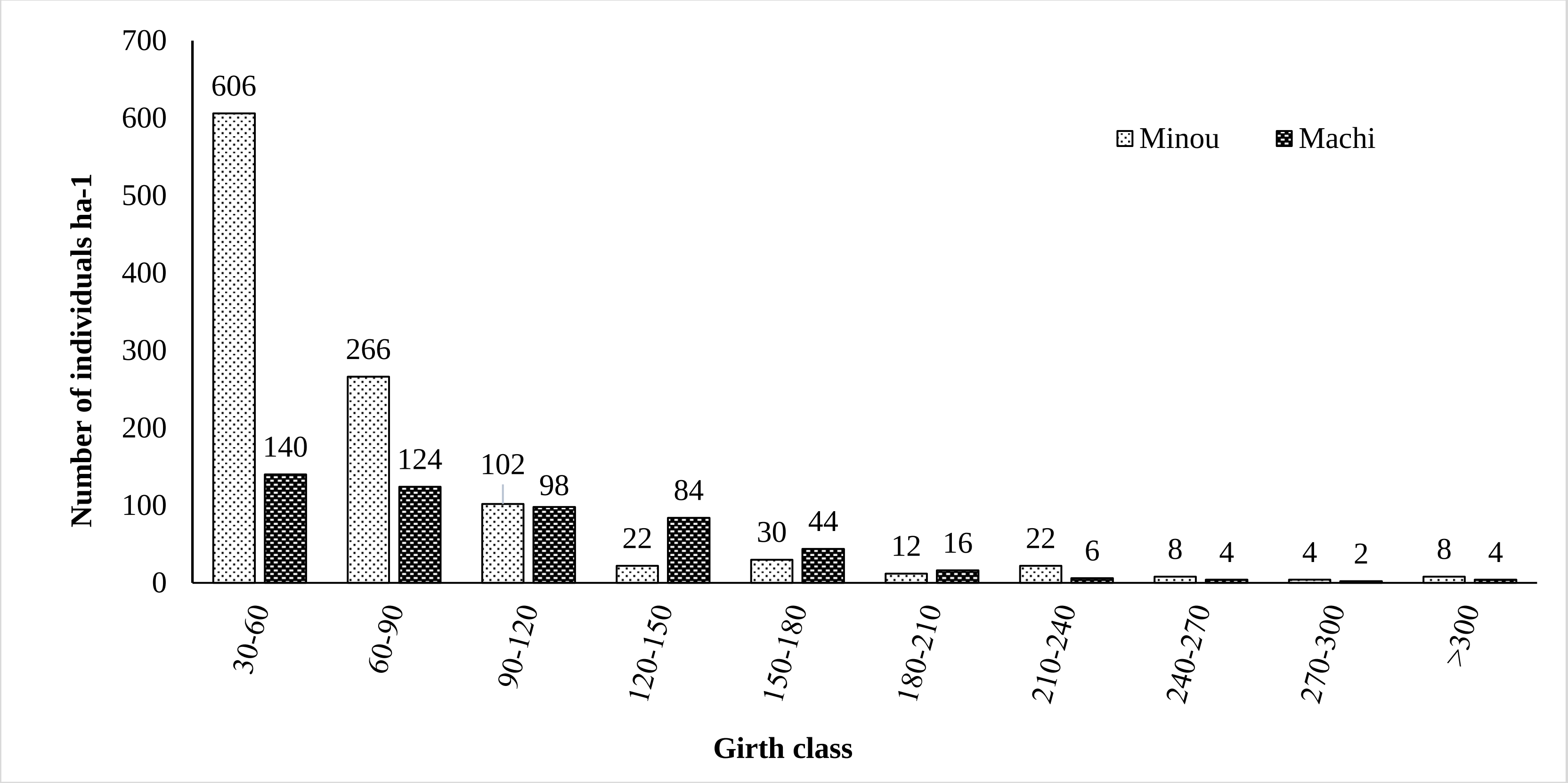


Fig. 3.5 Girth class density (ha^{-1}) distribution of tree species recorded in both the community forests of Manipur

3.3.2 Family diversity

Thirty-eight (38) families were recorded in the two community forests. Minou community forest recorded 35 families while Machi community forest has 21 families. Within the Minou community forest, the families Fagaceae and Moraceae emerged as co-dominant, with each family consisting of three species. On the other hand, tree species in the Machi community forest predominantly comprised under family Moraceae, with eight species, followed by Fabaceae with seven species. When considering the combined data from both community forests, the family Moraceae displayed the highest species count, containing a total of 8 species (Fig. 3.6). When focusing solely on fruit tree species, a total of 31 species from 26 genera and 21 families were recorded. Among these families, Moraceae demonstrated the highest number of documented species within both community forests, amounting to a total of five species (Fig. 3.7), representing five species in Minou community forest and three species in Machi community forest. This information is useful for understanding taxonomic diversity of plant species present in the community forests and provides insight into the distribution of different families and genera within them.

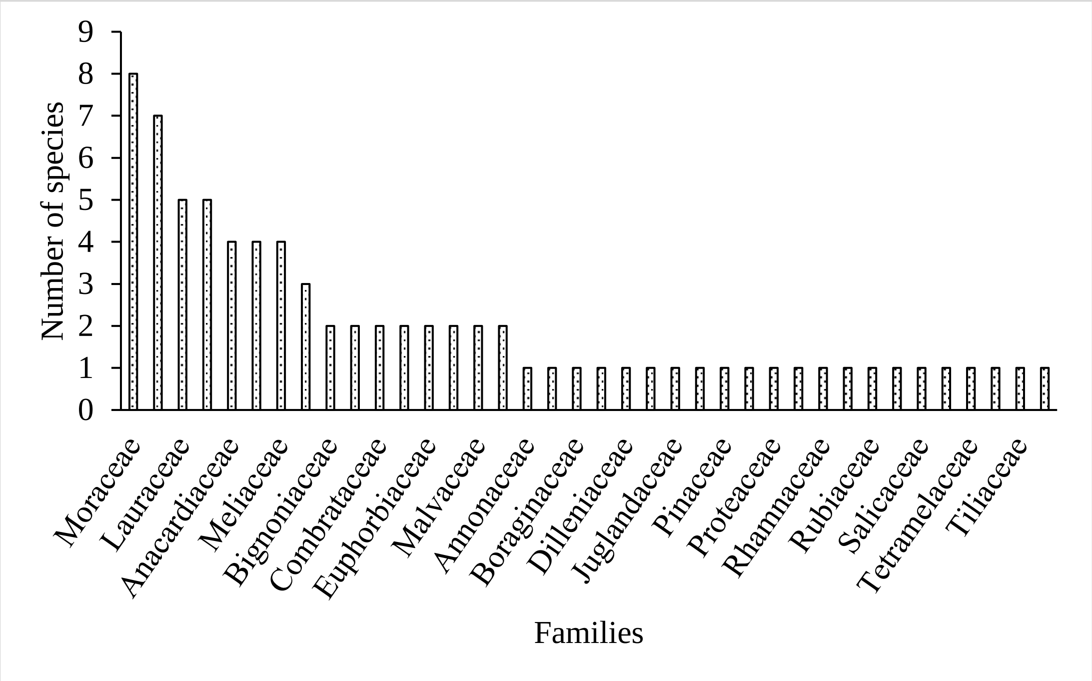


Fig. 3.6 Family diversity of tree species accounted from the two community forests of Manipur.

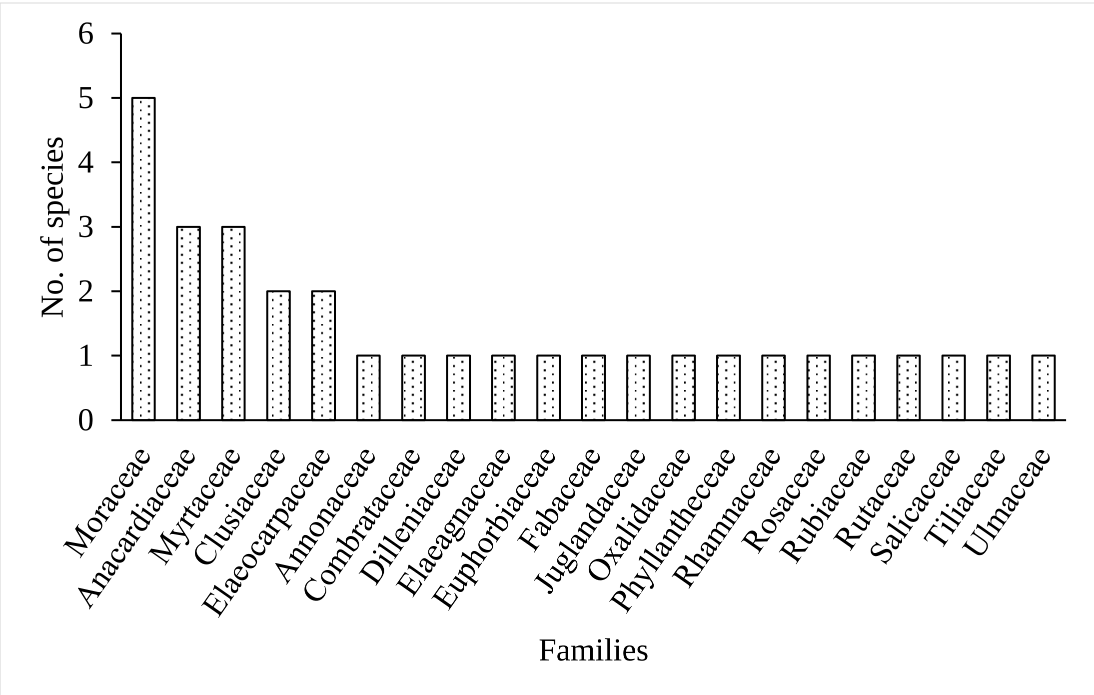


Fig. 3.7 Family diversity of fruit tree species (edible fruits) recorded in the two-community forests of Manipur.

3.3.3 Species diversity indices

Table 3.3 provides details on the species diversity observed in both the study sites. Margalef's species richness index (SR) was calculated and found to be 13.03 in Minou community forest and 12.22 in Machi community forest. The Shannon-Weiner diversity index (H') was approximately the same in both the community forest (Minou 3.89) and (Machi 3.9). The Simpson's index of dominance (C_D) was recorded as 0.04 in Minou community forest and 0.03 in Machi community forest. The Pielou's evenness index (e) varied between the two sites, with Machi community forest showing an index of 0.54 and Minou community forest showing an index of 0.88. The Whitford index in both community forests was >0.05, indicating a contagious pattern in the distribution of species.

Table 3.3 Species diversity indices recorded in the two community forests.

Diversity indices	Community forests	
	Minou	Machi
No. of species	83	69
No. of genera	59	29
No. of families	35	21
Density ha^{-1}	1084	522
Basal area ($m^2 ha^{-1}$)	78.89	68.96
Margalef's richness index (SR)	13.03	12.22
Shannon Index (H')	3.89	3.9
Simpson’s index dominance (CD)	0.04	0.03
Pielou's evenness (e)	0.88	0.54
Whitford index (WI)	0.12	0.16

The community forests were evaluated for species similarity and dissimilarity using the Sorensen index, which produced values of 0.37 and 0.63, respectively. The Sorensen similarity index measures the degree of overlap between two populations by calculating the ratio of the number of shared species relative to the total number of species in both populations. The index ranges from zero (no overlap) to one (complete overlap), where a score of 1 indicates that the two communities have all species in common, while a score of 0 indicates that they share no species. Conversely, in a dissimilarity index, a score of 1 represents completely different communities. Based on these results, it can be inferred that the two study areas have significantly different tree diversities.

The correlation analysis revealed a positive relationship between density, frequency, basal area, and diversity (Shannon-Wiener index, H', and Simpson's index, CD) in both study areas (Table 3.4 and 3.5). Significant positive relationships (<0.01) were observed between density and frequency, as well as between density and both Shannon-Wiener and Simpson indices, in both community forests. Similarly, significant positive relationships were found between frequency and both Shannon-Wiener and Simpson indices, as well as between Shannon-Wiener and Simpson indices themselves. However, no significant associations were detected between basal area and any of the other variables.

Table 3.4 Correlation among density, frequency, basal area, and diversity indices recorded in the Minou community forest community.

Diversity indices	Density	Frequency	Basal area	Shannon index	Simpson's index of dominance
Density	1				
Frequency	.94**	1			
Basal area	0.28	0.32	1		
Shannon index	.97**	.98**	0.31	1	
Simpson's index of dominance	.93**	.78**	0.22	.82**	1

** Correlation is significant at the 0.01 level (2-tailed).

Table 3.5 Correlation among density, frequency, basal area and diversity indices recorded in the Machi community forest.

Diversity indices	Density	Frequency	Basal area	Shannon index	Simpson's index of dominance
Density	1				
Frequency	.99**	1			
Basal area	0.55	0.6	1		
Shannon index	.99**	.97**	0.5	1	
Simpson's index of dominance	.95**	.94**	0.58	.88**	1

** Correlation is significant at the 0.01 level (2-tailed).

3.3.4 Fruit diversity and their market value

A total of 31 fruit species, representing 26 genera across 21 families are presented in Table 3.6 along with their fruiting season and market value. *Garcinia pedunculata* Roxb. was found to be the costliest among the recorded fruit tree species, with a price ranging from approximately Rs. 60-100/kg, followed by *Juglans nigra* L. at Rs. 50-80/kg. Vendors have claimed that *Rhus semialata* Murr, *Phyllanthus emblica* L., *Garcinia pedunculata* Roxb., and *Tamarindus indica* L. are readily available in the market throughout the year. However, *Garcinia xanthochymus* Hook.f., *Antidesmus bunius* (L.) Spreng, *Arthocarpus lakoocha* Roxb., *Arthocarpus heterophyllus* Lam., and *Terminalia chebula* Retz. were observed to be rare in local markets. *Annona reticulata* L., *Dillenia indica* L., *Flaccurtia jangomas* (Lour.) Raeusch., *Syzgium* sps., and *Pyrus pashia* Buch.-Ham. ex D. Don. are not sold commercially but were harvested from wild and consumed by the local people. It is common to sell fresh wild edible fruits, but *Rhus semialata* Murr and *Terminalia chebula* Retz. were sold in dried form and available throughout the year though their prices varying seasonally.

Table 3.6 Fruiting season and market prices of wild edible fruit tree species found in the Minou and Machi community forest.

Sl. No.	Name of the fruit species (Family)	Vernacular name (Manipuri/Maring)	Common name	Fruiting Season	Average price at local marke (Rs.)
1	*Annona reticulata* L. (Annonaceae)	Sitaphal/Mangkrak-hei	Red custard apple	May-July	---
2	*Antidesma bunius* (L.) Spreng *(Phyllantheceae)*	Heiyen/Theikron	Big nay	Oct-Nov	15-20/Kg
3	*Arthocarpus heterophyllus* Lam. *(Moraceae)*	Theibong/Theipong	Jack fruit	May-June	4-5/pc
4	*Arthocarpus lakoocha* Roxb. *(Moraceae)*	Heiru-kothong/Mu-hei	Lakoocha/Monkey Jack	Sept-Nov.	20-30/kg
5	*Averrhoa carambola* L. *(Oxalidaceae)*	Heinoujom	Starfruit	Sept-Oct	25-30/Kg
6	*Baccaurea sapida (Roxb.)* Mull-Arg. *(Phyllantheceae)*	Motok-hei/Fekhei	Burmese grape	March-April	30-50/bunch
7	*Citrus maxima* Merr. *(Rutaceae)*	Nobab/Hashi-hei	Pomelo	Oct-Dec	10-15/Kg
8	*Dillenia indica* L. (Dilleniaceae)	Heigree	Elephant apple	Dec.-April	---
9	*Elaeagnus conferta* Roxb. *(Elaeagnaceae)*	Heiyai/Parwa-hei	Wild Olive	March-April	20-30/Kg
10	*Elaeocarpus floribundus* Bl. *(Elaeocarpaceae)*	Chorphon	Indian Olive	Jan-March	10-20/Kg
11	*Ficus auriculata* Roxb. *(Moraceae)*	Heibong/Teipung	Fig tree	May-June	10-20/Kg
12	*Ficus cunia* Buch. -Ham.ex Roxb *(Moraceae)*	Heirit/Chir-hei	Fig tree	June-july	30-40/Kg

Table 3.6 (Contd.) Fruiting season and market prices of wild edible fruit tree species found in the Minou and Machi community forest.

Sl. No.	Name of the fruit species (Family)	Vernacular name (Manipuri/Maring)	Common name	Fruiting Season	Average price at local market (Rs.)
13	*Ficus racemose* L. *(Moraceae)*	Heipa/Ba-hei	Cluster Fig	May-June	10-20/Kg
14	*Flaccurtia jangomas* (Lour.) Raeusch. *(Salicaceae)*	Heitroi/Theikantung	Puneala plum	Nov-Jan	….
15	*Garcinia pedunculata* Roxb. *(Clusiaceae)*	Heibung/Changnaihei	Purple mangosteen	March-April	60-100/Kg
16	*Garcinia xanthochymus* Hook.f. *(Clusiaceae)*	Heirangoi/Theishor-hei	Yellow mangosteen	Oct-Nov.	30-40/Kg
17	*Juglans nigra* L. *(Juglandaceae)*	Heijuga/Khaihei	Walnut	Aug-Sept	50-80/Kg
18	*Mangifera indica* L. *(Anacardiaceae)*	Heinou	Mango	April-June	40-50/Kg
19	*Microcos paniculata* L. *(Tiliaceae)*	Heitup/Heituk	Wild Apple	Oct-Nov	20-30/Kg
20	*Phyllanthus emblica* L. *(Phyllantheceae)*	Heikru/Puklu	Gooseberry/Amla	Dec-April	10-20/Kg
21	*Psidium guajava* L. *(Myrtaceae)*	Pungdol/Pungton	Guava	Nov-Dec	15-20/Kg
22	*Pyrus pashia* Buch. -Ham. ex D. Don. *(Rosaceae)*	Cherry/Khurshi	Black Cherry	Aug-Oct.	….
23	*Rhus semialata* Murr. *(Anacardiaceae)*	Heimang/Kongba	Nutgall tree	Oct-Nov	50-60/Kg
24	*Solanum betaceum* Cav. (Solanaceae)	Ukhamen-ashinba/Naga-tomato	Tree tomato	Nov.-Jan.	30-40/Kg

Table 3.6 (Contd.) Fruiting season and market prices of wild edible fruit tree species found in the Minou and Machi community forest.

Sl. No.	Name of the fruit species (Family)	Vernacular name (Manipuri/Maring)	Common name	Fruiting Season	Average price at local market (Rs.)
25	*Spondias pinnata* (L.f.) Kurz *(Anacardiaceae)*	Heining/Tonto	Wild Mango	Sept-Oct	10-15/Kg
26	*Syzygium cumini* (L.) Skeels (Myrtaceae)	Jam/Muiril-hei;Jamhei	Jambul/Java/Mala bar Plum	Sept-Oct	10-20/Kg
27	*Syzgium sps. (Myrtaceae)*	Marit-hei	….	Sept-Oct	….
28	*Tamarindus indica* (L.) *(Fabaceae)*	Mangi-hei	Tamarind	Sept-Oct	10-20/Kg
29	*Terminalia chebula* Retz. *(Combrataceae)*	Manahei/Chopraheikru	Shilikha	March-April	1-2/Piece
30	*Vangueria spinosa* (Roxb. ex Link) Roxb. *(Rubiaceae)*	Heibi/Heipi	Muyna	Nov-Dec	20-25/Kg
31	*Ziziphus mauritiana* Lamk. *(Rhamneceae)*	Boroi	Indian jujube	Oct.-Feb.	15-30/Kg

3.3.5 Medicinal properties of wild edible fruits

Information on the mode of consumption and associated health benefits of wild edible fruits are provided in Table 3.7. It has been shown that majority of the wild edible fruits are eaten either fresh or preserved as pickles. These fruits are well-known in the locality for their diverse health benefits and medicinal properties, including their ability to alleviate diabetes, a condition that is becoming an increasing health problem. These fruits have reportedly been used by many people as a tonic to prevent skin and stomach-related discomfort, among other ailments. Additionally, the decoction of these fruits employed for the treatment for various ailments. Moreover, it is interesting to note that the root and other parts of the *Garcinia xanthochymus* Hook.f. are reportedly used in treatment of allergic, intestinal, and thyroid disorders. However, the fruit and leaves are the main plant's part used for food and medicine. Unfortunately, there was no information available on the health benefits of *Annona reticulata* L., *Spondias pinnata* (L.f.) Kurz, and *Syzgium* sp. from the locality.

It has been recorded that 31 fruit tree species could treat 25 different health ailments (Fig. 3.8). Majority of the species are used for the treatment of dysentery followed by constipation, infectious diseases, toothache and skin diseases. For the treatment of dysentery and constipation i 9 and 6 species respectively, were utilized. The species that are used in treatment of dysentery are *Ficus auriculata* Roxb., *Ficus racemosa* L., *Juglans nigra* L., *Phyllanthus emblica* L., *Psidium guajava* L., *Pyrus pashia* Buch. -Ham. ex D. Don., *Rhus semialata* Murr., *Syzygium cumini* (L.) Skeels, and *Ziziphus mauritiana* Lamk. While the six species used in constipation are *Arthocarpus heterophyllus* Lam., *Citrus maxima* Merr., *Elaeocarpus floribundus* Bl., *Psidium guajuva* L., *Solanum betaceum* Cav., and *Tamarindus indica* (L.).

Different parts of wild edible fruit trees are utilized for the treatment of various ailments (Table 3.7). The leaves and barks of *Antidesmus bunius* (L.) Spreng serve as an antidote for snake poison, while the fruit itself is not used for the same purpose. Conversely, the ripe fruits of *Arthocarpus heterophyllus* Lam. are specifically given to relieve constipation, and the milky latex derived from the tree is applied topically to ulcers and insect bites. Similarly, *Averrhoa carambola* L. is utilized in different treatments, with its fruits, leaves, and seeds playing a role in addressing conditions such as fever, urinary stone cases, bleeding piles, asthma, and jaundice.

Table 3.7 Mode of use and their associated health benefits of wild edible fruit trees

Sl. No.	Name of the fruits	Vernacular name (Manipuri/Maring)	Common Name	Mode of use	Health benefits and ailments
1	*Annona reticulata* L.	Sitaphal/ Mangkrak-hei	Red custard apple	Ripe fruits are consumed	No information found
2	*Antidesma bunius* (L.) Spreng	Heiyen/Theikron	Big nay	Ripe fruits are edible with acidic sourness and mainly consumed as chutney.	Leaves and barks are used as antidote to snake poison
3	*Arthocarpus heterophyllus* Lam.	Theibong/Theipong	Jack fruit	Ripe fruit pulps are consumed raw and seeds are eaten boiled and roasted.	Ripe fruits are given to relieve constipation. The milky latex of the tree locally used to apply on ulcers and insect bites.
4	*Arthocarpus lakoocha* Roxb.	Heiru-kothong/ Mu-hei	Lakoocha/Monkey Jack	Ripe fruits are taken raw mainly in the form of chutney	The bark of the fruit tree is used to heal pimples, boils, skin cracks, and headache.
5	*Averrhoa carambola* L.	Heinoujom	Starfruit	Matured fruits are consumed raw with salt and chilly, also as dried pickle.	Fruits, leaves, and seeds are utilized in different treatments such as fever, urinary stone cases, bleeding piles, asthma, and jaundice.
6	*Baccaurea sapida (Roxb.)* Mull-Arg.	Motok-hei/Fekhei	Burmese grape	Ripe fruits are eaten raw	Used as digestive
7	*Citrus maxima* Merr.	Nobab/Hashi-hei	Pomelo	Matured fruits are consumed as the fruit itself or as chutney	Fruits are used in indigestion, constipation, and consuming few segments of the fruit controls blood sugar level. Decoction of dried fruit peel is also utilized in coughing.

Table 3.7 (Contd.) Mode of use and their associated health benefits of wild edible fruit trees

Sl. No.	Name of the fruits	Vernacular name (Manipuri/Maring)	Common Name	Mode of use	Health benefits and ailments
8	*Dillenia indica* L.	Heigree	Elephant apple	Matured fruits are cooked with meat	Decoction of fruit with rice water is used as shampoo to cure dandruff and hair fall
9	*Elaeagnus conferta* Roxb.	Heiyai/Parwa-hei	Wild Olive	Ripe fruits are juicy, acidic, and tasty. Eaten as fresh or pickled, juice, or jam.	Fruits are used as digestive
10	*Elaeocarpus floribundus* Bl.	Chorphon	Indian Olive	Fruits are eaten raw and cooked for decoction. Used for pickles and chutney.	Fruits are used as antiseptic and in constipation and indigestion. Young leaves are used in pile treatment.
11	*Ficus auriculata* Roxb.	Heibong/Teipung	Fig tree	Ripe fruits are eaten raw	Leaves are given for stomach disorder. Latex is used to apply on boils.
12	*Ficus cunia* Buch. -Ham.ex Roxb	Heirit/Chir-hei	Fig tree	Ripe fruits are eaten fresh.	Unripe fruits are given for dysentery
13	*Ficus racemose* L.	Heipa/Ba-hei	Cluster Fig	Ripe fruits are eaten raw	Fruits are good for diabetes, stomach-ache, and lung disease. Locally, latex is used to applied for boils.
14	*Flaccurtia jangomas* (Lour.) Raeusch.	Heitroi/Theikantung	Puneala plum	Ripen fruits are consumed raw	Fruits are given to diabetic patient. Leaves and bark are used in bleeding gums, toothache, and sore throat.
15	*Garcinia pedunculata* Roxb.	Heibung/Changnaihei	Purple mangosteen	Unripe fruits are mainly cooked and consumed as digester during ceremonial gatherings.	Gout, arthritis, stone case, strong teeth and tight gum, digestive and stomach disorder.

Table 3.7 (Contd.) Mode of use and their associated health benefits of wild edible fruit trees

Sl. No.	Name of the fruits	Vernacular name (Manipuri/Maring)	Common Name	Mode of use	Health benefits and ailments
16	*Garcinia xanthochymus* Hook.f.	Heirangoi/ Theishor-hei	Yellow mangosteen	Ripe fruits are edible with acidic sourness, believed to be the tastiest fruit as mentioned in Lai Haraoba festival. Also consumed as chutney.	Traditionally seeds are prescribed in piles, dysentery, and intestinal disorder. Seeds and other parts of the tree are also found to be used in tonsil infection treatment, allergy, and thyroid related disorder.
17	*Juglans nigra* L.	Heijuga/Khaihei	Walnut	Traditionally mature fruits are boiled and sundried then consumed	The fruits are used as tonic and skin softening agent. Leaves are astringent, tonic and anthelmintic. Leaves and barks are used in toothache and dying hair colour
18	*Mangifera indica* L.	Heinou	Mango	Both ripe and unripe fruits are eaten freshly, cooked, or uncooked.	Fruit pulp is in treating skin diseases. Fumes from burning leaves, inhaled in cases of throat infection.
19	*Microcos paniculata* L.	Heitup/Heituk	Wild Apple	Fruits are used for pickles and candy.	Fruits are used in indigestion, dysentery, mouth ulcer and typhoid.
20	*Phyllanthus emblica* L.	Heikru/Puklu	Gooseberry/Amla	Fruits are eaten raw as well as pickle. And are boiled with rice water for hair cleanser.	Fruits are given in diarrhoea, dysentery, haemorrhage, anaemia, and jaundice. Fruits are used in cough, constipation, bleeding gums, piles and used as brain and nerve tonic in blood diseases.

Table 3.7 (Contd.) Mode of use and their associated health benefits of wild edible fruit trees

Sl. No.	Name of the fruits	Vernacular name (Manipuri/Maring)	Common Name	Mode of use	Health benefits and ailments
21	*Psidium guajava* L.	Pungdol/Pungton	Guava	Both ripe and unripe fruits are taken raw and also consumed as jam	Fruit is tonic, cooling and laxative, useful in bleeding gums. Eating tender shoot is suggested for dysentery.
22	*Pyrus pashia* Buch. -Ham. ex D. Don.	Cherry/Khurshi	Black Cherry	Ripe fruits are taken raw	Fruit juice is astringent and used to treat dysentery, digestive disorder, sore throat, irritability, abdominal pain, anaemia.
23	*Rhus semialata* Murr.	Heimang/Kongba	Nutgall tree	Matured and dried fruits are used for brown sugar candy and powdered pickles. Decoction is used as hair cleansers.	Kidney trouble, urinary complain, antiviral, antibacterial, diarrhoea, constipation, antioxidant activities, and as a digestive.
24	*Solanum betaceum* Cav.	Ukhamen-ashinba/Naga-tomato	Tree tomato	Ripe fruits are cooked as vegetables and chutney	No information found
25	*Spondias pinnata* (L.f.) Kurz	Heining/Tonto	Wild Mango	Ripe and unripe fruits are used for pickles and chutney	Bark extract is taken against dysentery and diarrhoea. Fruit pulp is good for indigestion.

Table 3.7 (Contd.) Mode of use and their associated health benefits of wild edible fruit trees

Sl. No.	Name of the fruits	Vernacular name (Manipuri/Maring)	Common Name	Mode of use	Health benefits and ailments
26	*Syzygium cumini* (L.) Skeels	Jam/Muiril-hei;Jamhei	Jambul/Java/ Malabar Plum	Ripe fruits are eaten raw	The seeds are used in treating diarrhoea or dysentery.
27	*Syzgium sps.*	Marit-hei	….	Ripe fruits are eaten fresh.	No information found
28	*Tamarindus indica* (L.)	Mangi-hei	Tamarind	Matured fruits are eaten raw. Fully ripen fruits are cooked or made into sweet pickle.	Decoction of fruits are used in treating acidity, constipation, cough and cold.
29	*Terminalia chebula* Retz.	Manahei/Chopraheikru	Shilikha	Fresh and dried fruits are eaten raw	Fruits are used in treating dry cough, throat infection, toothache and gum-bleeding. Barks are used as tonic.
30	*Vangueria spinosa* (Roxb. ex Link) Roxb.	Heibi/Heipi	Muyna	Young leaves are ingredient of traditional salad (singju) and hair cleanser.	Cooked leaf used for intestinal worm. Leaf paste is used for local application on head in hoarseness.
31	*Ziziphus mauritiana* Lam	Boroi	Indian jujube	Ripe fruits are eaten or make pickles or dried.	Dried fruits are recommended for treating burning sensation and blood impurities. Bark of the tree used in dysentery and body pain.

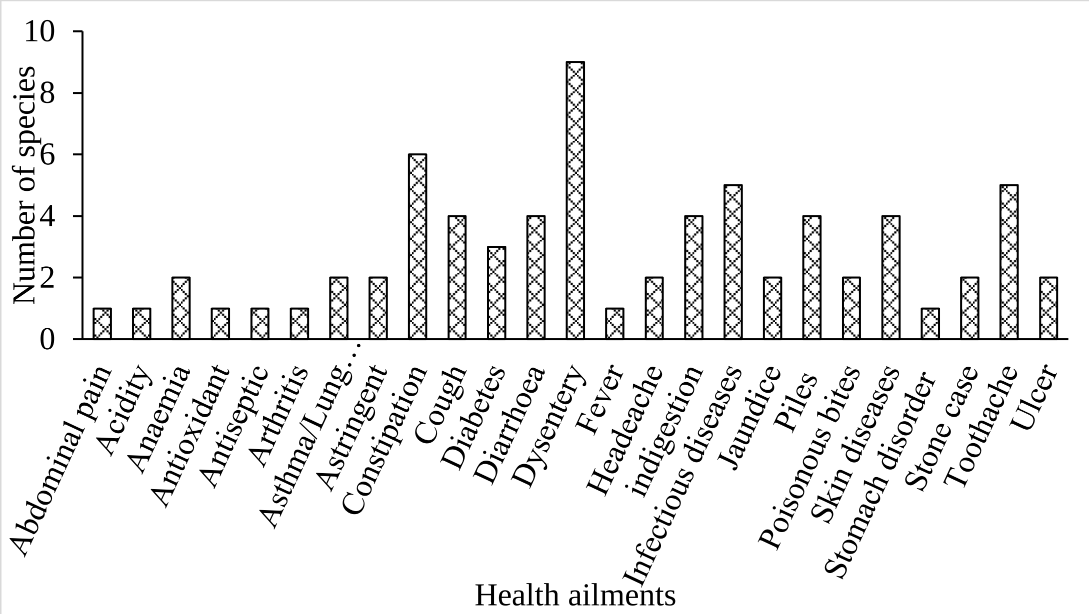


Fig. 3.8 Number of species used for the treatment of various health ailments

3.4 DISCUSSION

3.4.1 Tree species composition and community quantitative parameters

A total of 124 tree species were recorded from the two-community forest of Manipur. 83 tree species were documented in the Minou community forest of which 74 were identified while from the Machi community forest 69 tree species were recorded. The recorded tree species in the community forest of Manipur is lower than the tropical deciduous forest (135 species ha^{-1}) [36], tropical moist forests of Mizoram (125 tree species ha^{-1}) [37], tropical forests of Barak valley (222 tree species ha^{-1}) [38], Maharashtra (168 tree species ha^{-1}) [39] , different forest in Andhra Pradesh (207 species ha^{-1}) [40], and the tropical dry deciduous forest (149-246 species ha^{-1}) [41,42] and eastern Himalayan region of Mizoram (133 tree species ha^{-1}) [43], but is closely comparable with the tree diversity recorded in tropical wet evergreen forest (94 tree species ha^{-1}) [44] and sub-tropical forest ecosystem of Manipur (88 tree species $ha^{-}1$) [45] and the scared groves of Manipur (96 woody species ha^{-1}) [46]. However, the tree diversity of the present study recorded higher than the sub-tropical forest of Manipur (43 species ha^{-1}) [47], the semievergreen forest of Manipur (4 tree species ha^{-1})[48], the moist deciduous forest of Northern India (11 species ha^{-1}) [49], the lowland forest of Eastern Himalaya (69 species ha^{-1}) [50], and sacred groves of Jaintia hills of Meghalaya (32 tree species ha^{-1}) [51].

The number of tree species present in the two different community forests varies depending on a range of biotic and abiotic factors, as well as the conservation techniques practices by the community. The Minou community forest has a higher species count, potentially because of differences in elevation [52] and different levels of anthropogenic pressure and varying topographical structure [53]. However, both community forests are protected by community laws in order to fulfil subsistence requirement from forest resources that aims to improve the welfare of their respective communities. The local people earn a livelihood by harvesting forest products like wild fruits and vegetables. *Quercus serratus* L. was the most predominant species in the Minou community forest and these trees were being grown by local people and harvested for firewood in Manipur [54,55]. Furthermore, *Cinnamomum verum* J. S. Presl and *Juglans nigra* L. were recorded as the dominant species in Machi community forest. *Cinnamomum verum* which is a non-native species, suggesting that it is mainly grown for its economic value as a spices [56]. Observations revealed that there was biotic interference in the forest in terms of farming and cattle grazing that led to habitat destruction in the surrounding area. This interference played a significant role in the decline of the forest's composition [57]. The conversion of forests into other land uses has resulted in the degradation of natural resources of the forests, loss of biodiversity, and contributed to climate change [58,59].

The study of plant communities relies on crucial ecological characteristics such as quantitative parameters including frequency, density, abundance, and basal area [60,61]. In the Minou community forest, the density and basal area of the dominant species, *Quercus serratus* L., were recorded to be 130 ha^{-1} and 3.33 m^2 ha^{-1}, respectively. On the other hand, in Machi, the dominant species, *Cinnamomum verum* J. S. Presl and *Juglans nigra* L., had densities of 34 and 30 ha^{-1}, respectively.

Additionally, the basal areas of *Cinnamomum verum* J. S. Presl and *Juglans nigra* L. were recorded as 1.74 and 22.88 m^2 ha^{-1}, respectively. A study in tropical semievergreen forest of Manipur recorded *Dipterocarpus tuberculatus* as dominant tree species [48], and *Schima wallichii* as dominant tree species in subtropical forest of Manipur [47], and sacred groves of Manipur [62].

3.4.2 Family Composition

The family Moraceae, commonly known as the mulberry family, exhibits the highest species diversity within the community forests, comprising eight species and two genera. It is followed by the Fabaceae family with seven species and six genera, the Lauraceae family with five species and three genera, and the Myrtaceae family with five species and four genera, which are considered co-dominant. Additionally, the Anacardiaceae (4 species 4 genera), Fagaceae (4 species 2 genera), and Meliaceae (4 species 4 genera) are observed as co-dominant families in the two-community forest.

Moraceae is distributed worldwide, with many species found in tropical and subtropical regions including such important groups as *Artocarpus*, *Morus* and *Ficus* [63]. This family consists largely of flowering plants comprises 37 genera and approximately 1,100 species distributed throughout tropical and temperate regions worldwide [64]. It is a diverse family that includes trees, shrubs, and vines. The remarkable diversity observed within the Moraceae family can be attributed to its members' evolutionary adaptation to a wide range of ecological niches. Over time, different species within the family have developed unique morphological, physiological, and reproductive characteristics that enable them to thrive in various habitats and ecological conditions [65]. Furthermore, species belonging to the Moraceae family hold significant economic and medicinal value. They are recognized as a rich source of bioactive benzofuran derivatives [66]. The family is known for its diverse range of species, some of which have significant economic value. Economically, certain members of the Moraceae family are cultivated for their fruits, such as mulberries (Morus spp.) and figs (Ficus spp.), which are consumed fresh or processed into various products like jams, juices, and dried fruits. These fruits have commercial value and contribute to the agricultural and food industries [67]. Additionally, they have been used for centuries as traditional medicines. *Ficus* species have ethnopharmacological uses as anticancer and anti-inflammatory agents, spanning medieval, ancient, and modern times[68]. The Fabaceae family, commonly known as the pea family or legume family, represents the third largest families in the world. It is a diverse family that includes many economically important and ecologically significant plants [69]. Also possess numerous secondary metabolites with potential pharmacological and toxicological properties [70]. The Lauraceae family, commonly known as the laurel family, is a plant family comprising a diverse group of trees and shrubs [71]. This family is distributed worldwide, with a concentration in tropical and subtropical regions. Lauraceae includes several species of economic and ecological importance [72]. The Myrtaceae family, comprising trees, shrubs, and climbers, is economically valuable for timber, essential oils, and fruits, while also playing ecological roles in native forests and holding cultural significance in traditional medicine and cultural practices [73][74].

Similar to the present study, the Moraceae family was identified as dominant in the Hollongapar Gibbon Wildlife Sanctuary, Assam [75], as well as in the tropical forest of Assam [76]. On the other hand, the Lauraceae family was reported as dominant family in the natural forests and agroforests of south Meghalaya, Northeast India [77] and was also observed as one of the dominant family in Jiantia hills, Meghalaya [51]. Euphorbiaceae was found to be the dominant family in the lowland forest of the Himalayas [50], Poaceae was recorded as the dominant family in Manipur [48], Myrtaceae in tropical evergreen forest in Cachar district, Assam [78]. Naidu et al., (2018) reported Combretaceae was recorded as dominant in the deciduous forests of Northcentral Eastern Ghats, followed by Euphorbiaceae [36]. These findings highlight the diverse range of dominant species in different forest ecosystems, each playing a crucial role in maintaining the balance of the ecosystem.

3.4.3 Species Diversity Indices

Assessing species diversity is a crucial aspect of determining the significance of various species in forest communities. It is an essential component of studying ecosystem health, as it provides valuable information about the richness, evenness, and distribution of species within a given community. Researchers measure species diversity to gain insights into the relationships between different species and how the individuals are distributed among them [79]. A slight disparity in terms of species diversity was observed by examining Margalef's species richness range (12.22 and 13.03). Specifically, the Minou community forest with a richness index of 13.03, boasts a slightly greater number of species compared to the community with a richness index of 12.22 in Machi community forest. A report on species diversity indices in the natural deciduous forest concluded that a high level of species diversity suggesting the presence of a complex community [80]. The Margalef richness index for trees in the Northcentral Eastern Ghats Forest was found to range from 10.54 to 10.82 [81], while previous research in other tropical forests reported within the range of 4.54 to 23.41 [82]. The Shannon-Weiner Index assumes that individuals are randomly sampled from a large, independent population, and that all species are included within the sampling units. Despite this assumption being difficult to achieve in practice, particularly in ecological studies where species may be hard to locate or identify, the Shannon-Weiner Index remains a widely used and valuable tool for assessing biodiversity. It offers a comprehensive measure of species richness and evenness in a given community, taking into consideration both the number of species present and their relative abundances [83]. In the present study, the Shannon-Weiner diversity was 3.89 and 3.9 which falls within the range of 0.67 to 4.86 reported in tropical forests Indian sub-continent [36,84,85]. These values suggest that the present community forest is a species diverse system. The concentration of dominance, measured by Simpson's index, resulted 0.03 and 0.04 in the study, which is lower than the values observed in other forests, ranging from 0.64 to 1.34 [86], but similar to those in the Pualreng Wildlife Sanctuary, Mizoram [87]. The evenness index provides an indication of the dominance of one or a few species when it has low values, while high values indicate that the number of individuals belonging to each species is relatively equal [88]. The evenness index also refers to the degree of relative dominance of each species in the area, which is known as equitability. Pielou's evenness index is a measure of diversity that takes species richness into account, with a value of 0 indicating no evenness and a value of 1 indicating complete evenness [30]. The community forest's evenness ranged from 0.54 (Machi community forest) to 0.88 (Minou community forest). Minou had a higher level of biodiversity and a healthier ecosystem than Machi, as evidenced by the greater evenness observed in Minou community forest among the two community forests. The Whitford index showed a contagious pattern of distribution (cluster distribution) of species in both the study sites. Most common distribution pattern is the contagious distribution in nature [89]. A positive relationship between basal area, tree density, and species diversity suggests that the forest has experienced relatively low levels of disturbance and that the dominant tree species are not suppressing the growth of other species [90]. In this study, a significant correlation was observed between tree density and species diversity. Similarity index of trees in between Minou and Machi community forests was calculated to be 0.37 indicating that the two forests have distinct species richness and composition. Out of the recorded identified species, 28 were found to be common to both forests. The lower similarity index between the two forests may be due to differences in environmental conditions such as soil type, climate, topography, and disturbance history, which can affect plant species composition and abundance in an ecosystem.

3.4.4 Girth Class Diversity

The study observed that the richness and density of tree species decreased with increasing girth class in both the study areas, Minou and Machi community forests. The range of species richness having 27% to 56% recorded in 30-60 girth class in the present study was more than fragmented Moist Deciduous Forest Ecosystems of Northeast India, (29%) [91] and moist deciduous forest of Western Ghats was 24–26 species [92]. The distribution of girth classes revealed that in Minou community forest, the majority of tree individuals were represented in the 30-60 cm girth class, accounting for 56% of the total tree population. The second most abundant girth class was >60-90 cm, which represented 25% of the tree population, followed by >90–120 cm with 9%. The girth class >120 cm had less than 10% abundance. Similarly, in Machi community forest, the majority of the tree individuals were represented in the 30-60 cm girth class, accounting for 27% of the total tree population. The second most abundant girth class was >60-90 cm, which represented 24% of the tree population, followed by 90–120 cm with 19%. The girth class 120–150 cm represented 16% of the total tree population, while the girth class >150 cm had less abundance, accounting for only 15%. In addition, some higher girth classes were absent in Machi community forest. The decreasing trend of species diversity and density with the increase in girth class size corroborates with the studies in sacred groves in Manipur [46], Western Ghats, India [93][94], Malaysia [95], Coata Rica [96], and New guinea [97].

These findings suggest that as the girth class of trees increases, their abundance decreases, which could be attributed to factors such as natural competition for resources, human intervention, and environmental factors. The dominance of smaller girth classes in both study areas indicates that they may have a higher rate of survival, which could be attributed to their ability to better adapt to the prevailing environmental conditions thereby increasing population size and biomass in future. The study highlights the importance of monitoring the distribution and abundance of trees of different girth classes to ensure the conservation and management of forest ecosystems.

3.4.5 Fruit Diversity

The study recorded 31 wild edible fruit species of 26 genera and 21 families in two-community forest of Tengnoupal district. Minou community forest documented 29 fruit species, while Machi community forest recorded 18 species. Of these, 12 fruit species were found in both the community forest. The number of wild edible fruit species observed in these community forests was lower than that are observed in other areas like, Nagaland recorded 55 species [98], Mizoram recorded 60 species [99], Orissa recorded 56 species [10], Meghalaya recorded 66 species [100], Arunachal Pradesh recorded 52 species [101], Tripura recorded 86 species [102], northeast

Chhattisgarh recorded 80 species [103], Manipur recorded 49 species [18], and the Kom tribe of Manipur recorded 36 fruit species [104].

Analysing Tables 3.6 and 3.7, it becomes evident that rural communities rely on these fruits for consumption, income generation, and medicinal benefits. Additionally, Table 3.6 provides detail information on the local market price and seasonal availability of wild edible fruits. Villagers typically collect these fruits from natural habitat of forest areas and sell them directly by themselves or through small vendors. The majority of fruit species are in high demand, but their availability has decreased over the past few years, according to reports from fruit vendors. Similar observation was reported by Hazarika and Singh, (2018) [18]. According to vendors and shop owners, increasing number of micro scale entrepreneur for pickle/achar production may be one of the possible reasons for this decline. They buy fruits in bulk directly from collector and used it as a value-added ingredient. Additionally, individuals may be dissuaded from actively acquiring and selling these fruits due to the relatively low financial return, usually ranging widely from Rs. 10 to Rs. 100 per kg, resulting in a decline in the overall supply and availability in local markets.

It is noteworthy that the market value for wild edible fruits hasn't improved for the past decade [105]. Moreover, certain fruits, such as *Antidesma bunius* (L.) Spreng, *Citrus maxima* Merr., *Eugenia jambolana* Lam., *Ficus auriculata* Roxb., *Ficus racemosa* (L.), *Juglans nigra* (L), *Psidium guajava* (L.), *Solanum betaceum* Cav., and *Terminalia chebula* Retz., which were once readily available in nearby locality, are now being sold in markets. This may be due to the decline in number of individuals of these fruit species in local areas due to deforestation or rural development. Devi et al. 2010 [105] reported that *Dillenia indica* (L.) and *Flaccurtia jangomas* (Lour.) Raeusch. which were documented sold in the market were not available in any of the visited markets in Ima markets of Imphal Valley, Manipur during their survey.

3.4.5.1 Ethnomedicinal value of wild edible fruits

The practice of traditional healing, which adheres to a well-defined philosophy and set of guiding principles, is considered as the oldest form of structured medicine [106]. In north-east India, traditional medicine is an integral component of various ethnic communities [107,108]. Even in the twenty-first century, traditional herbal remedies remain an essential component of primary healthcare, as they are accessible, inexpensive, and generally have minimal adverse effects [109–111]. In fact, research has shown that around 70% of the Indian population relies on traditional medicine for their primary healthcare needs [112]. Moreover, the people of Manipur have a unique tradition of using medicinal plants, including wild edible fruits, to treat several primary health conditions, dating back to prehistoric times [107]. This knowledge is passed down orally from generation to generation, and the current study identified 31 wild edible fruits from the community forests, 28 of which were used for medicinal purposes. This demonstrates that the forest is a valuable repository of wild edible plants and fruits with medicinal properties. The 28 wild edible fruits are used to treat 26 different ailments, with nine species used for dysentery and six species used for constipation. Similar study from different region of Manipur also reported, 31 species of wild edible fruit used to treat dysentery [18], while 15 species from Nagaland reported medicinal properties [98]. There are 16 species known to treat dysentery and diarrhoea [99]. Furthermore, numerous medicinal plants are used to treat dysentery and diarrhoea in various regions of India, including 11 plants in Assam [113] and 54 species in Tamil Nadu [114]. In the present study, information on medicinal properties of wild edible fruits was gathered from a traditional herbal healer and local elders, who have extensive knowledge and experience of using these plants for medicinal purposes. They stated that the choice of plant parts and dosages for treatment depends on the patient's age and type of illness, and recovery times can vary among individuals. Previous studies on ethnomedicinal plants have shown that leaves are the most used part of the plant for preparing medicine and treating various health problems. This is because the leaves are sustainable and have more usability compared to other parts of the plant [107,115,116]. In the case of wild edible fruits, the current study found that the most consumed parts of the plant are the fruits, which is similar to the observation reported in Pakistan [117]. The local healer also mentioned that the current generation has less interest in this profession. However, many people of Manipur are still seeking remedies for their ailments from herbal medicine men, though people of Manipur are highly influenced by modern practices and widespread of allopathic medicine [118].

The present study highlights the medicinal values of these fruits to treat various ailments and emphasizes the importance of recognizing and preserving the community's traditional practices for future generations, as they continue to play a significant role in ensuring health security. Therefore, it is essential to study and document the knowledge of traditional healers and local elders to preserve the knowledge of the medicinal properties of plants and their indigenous treatment for a variety of health ailments.

3.5 DISTRIBUTION RECORD OF *SAPRIA HIMALAYANA* GRIFFITH

Community study often leads to discovery of new species or new distribution of species. During the field survey of tree community structure in Machi community forest, a rare root parasitic flowering plant "*Sapria himalayana*" (Fig. 3.9) was recorded and reported as new distribution record in Tengnoupal district [119]. *Sapria himalayana* Griffith. is an interestingly rare, endangered, and poorly understood holoparasitic angiosperm belonging to Rafflesiaceae family. Angiosperms are the most diverse group of plants that includes parasitic plants. However, there is a very limited study across the countries on diversity of parasitic angiosperms and underlying factors that influence its distribution in different habitats. Such plants specifically Sapria Griff. are restricted in distribution and are confined to virgin forests particularly in humid tropics [120]. The species was observed in two cluster at Machi community forest. The spectacular pinkish-red colour buds directly emerging from the host root of Tetrastigma vine (Fig. 3.10) was like the masterpiece in the habitats. It was observed that the area where this species grows were highly humid and moist, hence it is believed that it plays an important role in maintaining the forest floor. Through informal interview with the local people, it has been recorded that local people does not have any knowledge about the importance and utility of this holoparasitic plant. Moreover, they have no idea about the rarity and conservation status of the species and its habitats. Although, it is not clear whether the presence or elimination of this species affects the overall stability of the ecosystem, but it is very much clear that loss of any species will draws several undesirable effects in the community. Therefore, it is very essential to give awareness for conservation of these natural sites (Machi community forest), also to impart education about the value of this root parasitic angiosperm and its host plant to the local people. In fact, it is imperative to recognize the Machi community forest as the valued habitat of *S. himalayana* [119].

Fig. 3.9: Showing Natural habitat of *S. himalayana* in the Machi community forest (a), Flower buds (b), Female flower with ten bracts and buds (c), and Colour changes of the flower bracts (d).

Fig. 3.10 Host plant of *S. himalayana*, Tetrastigma vine in their natural habitat.

3.6 CONCLUSION

In this chapter, the tree composition, community parameters, family diversity, species diversity indices, fruit diversity, and medicinal importance of wild edible fruits in two community forests, namely Minou and Machi, have been examined.

In terms of tree composition and community parameters, both the Machi and Minou community forests exhibited a high level of taxonomic diversity. The Minou community forest was found to have 58 different genera spread across 35 families, while the Machi community forest contained 29 genera distributed among 21 families. The total number of identified species in both forests combined was 77, representing 61 genera belonging to 38 families. Moraceae was a dominant family in both forests, with Minou having three species and Machi having eight species. When considering both community forests together, Moraceae displayed the highest species count with eight species. Minou community forest had a higher tree density (1084 individuals ha^{-1}) compared to Machi community forest (522 individuals ha^{-1}). The dominant tree species in Minou community forest based on Importance Value Index (IVI) were *Quercus serratus* L., *Ficus religiosa* L., *Pinus khasya* Royle, *Schima wallichii* (DC.) Korth., and *Castanopsis indica* Roxb. ex Lindl. While, in Machi community forest, *Juglans nigra* L., *Cinnamomum verum* J. S. Presl., *Melanorrhoea usitata* Wall., *Pyrus* *pashia* Buch.-Ham. ex D.Don., and *Schima wallichii* (DC.) Korth. were the most dominant species. These species were the most prominent in terms of their overall importance within the community forest.

In the species diversity indices, Margalef's species richness index (SR) was 13.03 in Minou and 12.22 in Machi community forest. This indicates a slightly higher species richness in Minou compared to Machi forest. The Shannon-Weiner diversity index (H') was calculated to evaluate the overall diversity and evenness of species in the forests. The values for H' were found to be approximately the same in both forests, with Minou scoring 3.89 and Machi scoring 3.9. This implies that despite the difference in species richness, the distribution and abundance of species were relatively similar in both forests. Simpson's index of dominance (CD) was 0.04 in Minou and 0.03 in Machi community forest. These values indicate a slightly higher dominance of certain species in the Minou community forest compared to Machi. Pielou's evenness index (e) was employed to examine the relative abundance of species in the forests. Interestingly, the two sites exhibited contrasting values. Machi displayed an evenness index of 0.54, suggesting a relatively uneven distribution of species, while Minou exhibited an evenness index of 0.88, indicating a more uniform distribution of species. Additionally, the Whitford index, which assesses the spatial pattern of species distribution, indicated a contagious pattern in both the Minou and Machi community forests. This suggests that the species tended to cluster together rather than being randomly dispersed throughout the forests. Lastly, the Sorensen similarity index was utilized to compare the tree diversities between the Minou and Machi community forests. The results indicated significant differences in species composition and diversity between the two forests, implying that the two sites have distinct ecological characteristics in terms of tree species diversity.

A total of 31 fruit species from 26 genera and 21 families were recorded from the two-community forest of Manipur, *Garcinia pedunculata* Roxb. and *Juglans nigra* L. were the costliest fruits among them. Moraceae had the highest number of documented fruit species, with five species in total. These were consumed fresh or preserved as pickles and are known for their diverse health benefits and medicinal properties. Different fruit species were used to treat various health ailments, such as dysentery, constipation, infectious diseases, toothache, and skin diseases. The study identified 31 fruit tree species that could treat 25 different health ailments. Different parts of fruit trees, including fruits, leaves, barks, and seeds were utilized for medicinal purposes.

Overall, the findings highlight the rich tree diversity, species composition, and medicinal value of wild edible fruits in both the Minou and Machi community forests. The forests exhibited high taxonomic diversity, with distinct family compositions. The presence of common and unique tree species in each forest indicates the importance of conserving these habitats to preserve biodiversity and support local communities in terms of food security, income source and traditional medicine.

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