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Full Length Research Article

Species Diversity and Herbal Medicine Utilization of Mangrove Plants: A Comparative Study among Coastal Communities in Lampung

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ABSTRACT

Biodiversity and local wisdom in mangrove ethnopharmacology are essential to study as a basis for conservation and health development. The study objectives were determining mangroves' diversity and distribution, their use as herbal medicine, and their trusted medical properties. Vegetation analysis was employed to study the mangrove diversity. An interview and observation were conducted to study mangrove utilization. Mangrove diversity was determined by examining the diversity index. Mangrove utilization was determined by descriptive comparative analysis and calculating species use value, plant part value, and fidelity level. Total 28 species of mangroves from 15 families in Lampung. The highest mangrove diversity is in Lampung Timur (22 species; Shannon Index (H') = 1.93), followed by Pesawaran (21 species; H' = 1.96), Tulang Bawang (12 species; H' = 1.24), and Lampung Selatan (11 species H' = 0.90). Surprisingly, a species was used for different purposes in different areas. S. caeseolaris has the highest species use value of 0.1591. Leaves have the highest plant part value of 58%. *R. apiculata*, as an antiseptic, and *S. caseolaris*, as an antioxidant, have the highest fidelity level, 14%. Eight mangrove species trusted by the community have ten medical properties. This finding could be the basis for scientific studies to find new sources of medicine.

1. Introduction

As the most essential mangrove area in the world, Indonesia has a total mangrove forest area of 2.7 million ha or equivalent to 22.6% of the world's total mangrove area (Basyuni et al. 2022). Analyzing the state and potential of the region is a crucial first step in the management of mangrove areas (Arfan et al.2024). Mangrove flora in Indonesia consists of 157 species, including 52 species of trees, 21 species of shrubs, 13 species of lianas, seven species of palms, 14 species of grasses, eight species of herbs, three species of parasites, 36 species of epiphytes and three species of ferns (Basyuni et al. 2022). Mahmiah et al. (2016) highlight that Indonesia, known for its rich diversity of mangrove species, possesses a wealth of untapped potential, particularly in utilizing mangroves as sources of medicinal raw materials.

Using mangrove species in traditional medicine for preventive and therapeutic purposes has been a widespread practice in many regions worldwide (Vinoth et al. 2019). This is due to essential phytochemicals in mangrove plants, which hold considerable promise as pharmacologically active substances (Mitra et al. 2021). Secondary metabolites found in mangrove plant tissues, including alkaloids, phenolics, steroids, and terpenoids, have demonstrated toxicological, pharmacological, and ecological importance (Jairaman et al. 2019). Many studies have proven that mangrove plants can be a good source of herbal medicine (Das et al. 2015). The phytochemicals in mangroves are useful as bioactive, including anticancer, anti-tumor, anti-inflammatory, anti-viral, anti-fungal, anti-bacterial, and antidiabetic (Genilar et al. 2021). Using mangroves as herbal medicine in Indonesia is essential in supporting the Roadmap of the Indonesian Ministry of Health to reduce imports of national medicinal raw materials by 20% in 2026. Apart from having an impact on saving the country's foreign exchange, national drug independence is expected to increase the affordability of medicines for people with low incomes, which in 2022 will reach 26.36 million people (9.57% of the total population of Indonesia), where the majority (14.38 million people) live in rural areas (BPS 2023). Among Indonesia's poor population, fishing workers and traditional fishermen are professions with the lowest average income (Mamengko and Kuntari 2020). People experiencing poverty cannot meet basic needs such as shelter, clothing, food, and medicine (Maipita and Fitrawaty 2014). Optimizing the utilization of mangrove plants as a source of affordable herbal medicines has a strategic role in health development in Indonesia, especially in coastal areas, which are the center of poverty, and the potential of mangroves has not been utilized optimally.

Lampung is one of the provinces with important mangrove forest areas in Indonesia, with a total coastline length of 1,105 km and potential mangroves of 9,355 ha (Direktorat Konservasi Tanah dan Air KLHK RI 2021). Even though the area of mangroves in Lampung Province only covers 0.28% of the total area of Indonesian mangroves, which reaches 3,364,080 ha, mangrove forests in Lampung have special features because they grow in diverse ecosystems. Mangroves in Lampung grow in two different oceanographic conditions. The east coast of Lampung has a sloping beach due to silt sedimentation from large rivers that empty into the Java Sea. In contrast, the bay area facing the Sunda Strait has a tortuous coastline and becomes an estuary for small rivers (Pariwono 1999). The variability in site conditions along the coastal areas in Lampung fosters diverse plant species within the mangrove vegetation. This diversity and the mangrove species' wide range of adaptive capacities hold significant potential for producing bioactive compounds as secondary metabolites. These compounds have been shown to benefit human health considerably (Duryat 2024).

Moreover, as Indonesia's first transmigration destination began in 1905, Lampung has diverse ethnicities. There are more than 17 ethnic groups with a significant population living in Lampung Province (BPS Provinsi Lampung 2020). The diversity of mangrove resources, combined with the diversity of ethnicity and cultures, is expected to create a rich tradition of using mangroves as herbal medicinal. However, until now, data and information on using mangrove plants as herbal medicine in Lampung Province have never been reported.

Data and information about the diversity of mangrove plant species and their use as medicinal plants are essential to study and documented as a wealth of traditions in supporting science. Natural products hold great potential, which can lead to the discovery of new drugs (Yadav et al. 2014). Often, new sources of medicinal ingredients are found based on local wisdom that the community has practiced for generations. Various research results prove that mangrove plants used traditionally by coastal communities have proven to have bioactive compounds that are efficacious for treating diseases (Genilar et al. 2021). Information related to the community's efficacy and empirical use of medicinal plants can be used for further studies to determine the phytochemical content and their efficacy as medicine based on scientific knowledge. This study seeks to answer three basic questions, namely how the biophysical conditions and anthropogenic influences impact the diversity of mangrove species, the extent to which coastal communities have utilized mangrove plants as a source of herbal medicine, and how the relationship between the diversity of mangrove species and ethnic diversity affects the use of mangroves as medicinal plants. The study's objectives were to determine the diversity of species in mangrove forest vegetation and to study the diversity of the traditional use of mangroves as medicinal plants based on the local wisdom of the community in four mangrove centers in Lampung coastal areas.

2. Materials and Methods

2.1. Time and Location of Study

The research was conducted from November 2022 to January 2023 in four mangrove center areas in Lampung Province: Pesawaran (Sidodadi Village), Lampung Timur (Margasari and Pasir Sakti Village), Lampung Selatan (Pematang Pasir Village), and Tulang Bawang (Bumi Dipasena and Bumi Sentosa Village). The location of the study is shown in **Fig. 1**.

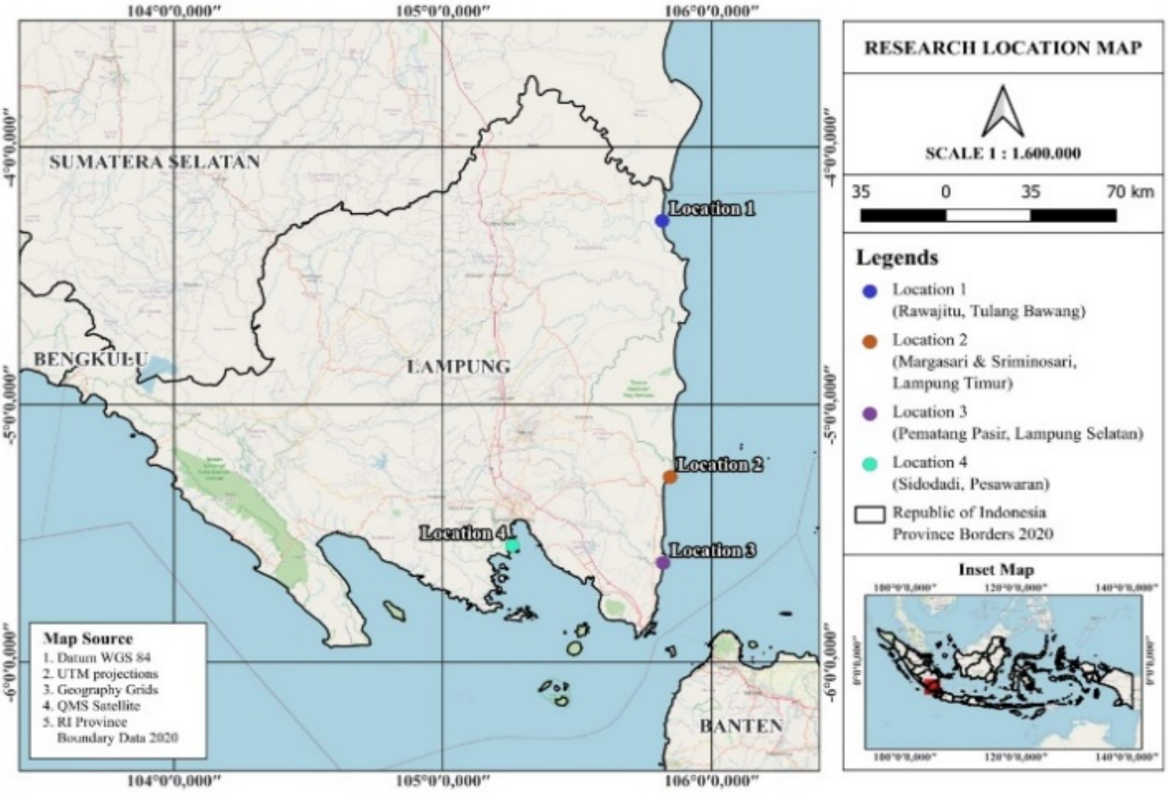

Fig. 1. Research location.

2.2. Sampling

The study was divided into two categories: sampling for vegetation analysis and sampling respondents from communities using mangrove plants as medicine. Sampling for vegetation analysis was carried out using the cluster sampling method (Hilmi et al. 2021). This method was chosen because, based on initial observations and map studies, it is known that in each study area, there are differences in mangrove plant species that are correlated with differences in site factors, which greatly affect the adaptability of mangrove species. These factors are the substrate, freshwater supply, and current sea status. In order to obtain a diversity that represents the population, each difference in site status that correlates with the diversity of mangrove species is then made into a separate cluster. Based on the preliminary study, 18 observation stations were established spread across four mangrove center areas, namely Pesawaran (3 stations), Lampung Timur (6 stations), Tulang Bawang (4 stations), and Lampung Selatan (3 stations). At each station, a sample plot is placed as a checkered lane with the length of the lane equal to the thickness of the mangrove forest. The starting point of the transect is positioned at the outermost edge of the mangrove vegetation closest to the open sea. From this point, a track line is established perpendicular to the shoreline, extending inland to the coastal area. Along each transect, 10 m × 10 m sample plots are alternately placed on either side, with a distance of 10 m between each plot. The plot method is a combination of the transect method and the plot method (Kusmana 2017). Placing sample plots along an elongated path aims to see the profile and ecology of mangrove vegetation based on the existing zones.

In order to select respondents from the community who use mangrove plants as medicine, sampling was carried out using the snowball sampling method (Kochnower et al. 2015). The snowball sampling method was chosen because currently, the use of mangrove plants as a herbal medicine has low popularity in society, generally only among the older generation who still have knowledge and skills in their utilization. Therefore, to capture all information related to the use of mangroves, probability sampling is less effective; based on that reason, snowball sampling was chosen. Snowball sampling is a valuable method for examining vulnerable groups or individuals who require special attention (Naderifar et al. 2017). To select the appropriate respondents, it is essential to identify a key informant recognized by the community for their use of mangroves as a medicinal resource. The key informants chosen as respondents should include traditional healers or shamans, community leaders or elders, elderly individuals with extensive knowledge, and agricultural extension officers (Heinrich and Jäger 2015).

2.3. Data Collecting

In each sample plot, data were collected on plant species identified using the "Guide to Introduction to Indonesian Mangroves" (Giesen et al. 2006). Information on the community's use of mangrove plants as medicine was obtained through in-depth interviews using a questionnaire. Data related to the use of medicinal plants by the community include (1) respondent's identity; (2) types of mangrove plants that are known by the community; (3) types of mangrove plants used by the community as medicinal plants; (4) plant parts or tissues used as medicinal; and (5) kind of diseases that can be cured or prevented by mangrove plants (species and plant parts that are effective for preventive and curative these diseases).

2.4. Data Analysis

Observational and interview data were tabulated to facilitate analysis. The composition of mangrove species' vegetation constituents was analyzed using descriptive analytic methods. Comparisons of using mangroves as medicinal plants in four mangrove center areas were analyzed using descriptive comparative methods.

The Shannon-Wiener diversity index (Shannon index) is used to determine species diversity at each growth stage (Odum 1993) and was calculated using Equation 1:

$$H' = -\sum_{i=1}^{s}(p_i ln\, p_i) \quad (1)$$

where p_i is the proportion (n/N) of individuals of a particular species found (n) divided by the total number of individuals found (N), *ln* is the natural log, *Σ* is the number of calculations, and *s* is the number of species.

Parameters related to the use of medicinal plants are analyzed as follows (Kurniawan and Jadid 2015):

a. Species Use Value (SUV) was calculated using Equation 2:

$$SUV=(\sum UVis)/ni \quad (2)$$

where *SUV* is the species that uses the plant's value, *ΣUVis* is the number of stated benefits of a species, and *ni* is the number of respondents interviewed.

b. Plant Part Value (PPV) was calculated using Equation 3:

$$PPV=\sum RU\ plant\ part/RU \quad (3)$$

where *PPV* is the plant part, *RU* is the total number of plant uses reported, and *RU plant part* is the number of uses reported per part of a medicinal plant.

c. Fidelity Level (FL) was calculated using Equation 4:

$$FL = \frac{Np}{N} \times 100 \quad (4)$$

where *FL* is the confidence level, *Np* is the number of respondents who mentioned the species for a particular use, and *N* is the total number of respondents who mentioned the species for various uses.

3. Results and Discussion

3.1. Diversity of Mangrove Species

Mangrove forests along the coastal areas in Lampung comprise 28 species from 15 families, with the highest species diversity found in East Lampung (**Table 1**). Of these, the majority (60.71%) are true mangroves, and most (60.71%) have a tree growth form. According to the International Union for Conservation of Nature (IUCN) Red List data, the majority (89.29%) of mangrove species found along the coastal areas in Lampung are categorized as Least Concern, with no species listed as Near Threatened (NT) or higher. The absence of species with endangered status suggests that the mangrove ecosystem in Lampung coastal areas has already lost vulnerable plant species, likely due to environmental degradation. The loss of mangrove species is driven by deforestation, habitat conversion, pollution, climate change, overexploitation, and pest and disease outbreaks (Maliq et al. 2017).

The primary distinction in mangrove species between the east and south coasts of Lampung lies in the presence of *Nypa frutican* and *Sonneratia alba*, found on the east coast but absent on the south coast. This difference arises because *N. frutican* and *S. alba* are brackish-water mangrove species that thrive along rivers where the water is brackish to nearly fresh. Communities of *Nypa* spp. or *Sonneratia* spp. typically dominate these zones (Giesen et al. 2006). The east coast of Lampung features a brackish water zone, resulting from its role as an estuarine convergence point for several major rivers (Way Mesuji, Way Tulang Bawang, Way Seputih, and Way Sekampung) that contribute substantial amounts of fresh water and silt sediments. Consequently, the coastal characteristics of this region are marked by a gentle slope due to silt deposition (Pariwono 1999).

Table 1. The composition of the species constituent mangrove vegetation in the four mangrove center areas in Lampung Province

No	Species	Family	Life Form	IUCN Status	Category	Area			
						PS	LT	TB	LS
1	*Acanthus ilicifolius*	Acanthaceae	Shrub	LC	true mangrove	+	+	+	+
2	*Avicennia alba*	Avicenniaceae	Tree	LC	true mangrove	+	-	-	-
3	*Avicennia marina*	Avicenniaceae	Tree	LC	true mangrove	-	+	+	+
4	*Acostricum sp*	Pteridaceae	Fern	DD.	true mangrove	-	+	-	-
5	*Bruguiera gymnorrhiza*	Rhizophoraceae	Tree	LC	true mangrove	+	+	-	-
6	*Ceriops tagal*	Rhizophoraceae	Tree	LC.	true mangrove	+	-	-	-
7	*Excoecaria agallocha*	Euphorbiaceae	Tree	LC	true mangrove	+	+	+	-
8	*Lumnitzera littorea*	Combretaceae	Shrub	LC	true mangrove	+	+	+	-
9	*Nypa frutican*	Arecaceae	Palm	LC	true mangrove	-	+	+	-
10	*Rhizopora apiculata*	Rhizophoraceae	Tree	LC	true mangrove	+	+	-	+
12	*Rhizopora mucronata*	Rhizophoraceae	Tree	LC	true mangrove	+	+	+	-
13	*Rhizopora stylosa*	Rhizophoraceae	Tree	LC	true mangrove	+	+	-	+
14	*Scyphiphora hydrophyllacea*	Rubiaceae	Shrub	LC.	true mangrove	+	-	-	+
15	*Sonneratia alba*	Sonneratiaceae	Tree	LC.	true mangrove	-	+	-	-
16	*Sonneratia caseolaris*	Sonneratiaceae	Tree	LC.	true mangrove	-	-	+	+
17	*Xylocarpus rumphii*	Meliaceae	Tree	LC.	true mangrove	-	+	-	-
18	*Deris trilofia*	Leguminoceae	Shrub	DD.	mangrove associates	+	+	+	+
19	*Erythrina variegata*	Leguminoceae	Tree	LC.	mangrove associates	+	+	-	-
20	*Ficus superba*	Moraceae	Tree	LC.	mangrove associates	+	-	-	-
21	*Hibiscus tiliaceus*	Malvaceae	Tree	LC.	mangrove associates	+	+	+	-
22	*Ipomoea pes-caprae*	Convolvulaceae	Shrub	LC.	mangrove associates	+	+	+	+
23	*Melanthera biflora*	Asteraceae	Shrub	LC.	mangrove associates	+	+	-	+
24	*Morinda citrifolia*	Rubiaceae	Tree	LC.	mangrove associates	+	+	+	+
25	*Pluchea indica*	Asteraceae	Shrub	DD	mangrove associates	+	+	-	-
26	*Terminalia catappa*	Combretaceae	Tree	LC.	mangrove associates	+	+	+	+
27	*Thespenia populnea*	Malvaceae	Tree	LC.	mangrove associates	+	+	-	-
28	*Wedelia biflora*	Asteraceae	Shrub	LC.	mangrove associates	+	+	-	+
	Sum of Species					21	22	12	11

Notes: PS is Pesawaran, LT is Lampung Timur, TB is Tulang Bawang, LS is Lampung Selatan, LC is Least Concern, DD is data deficient, (+) indicates species found and (-) indicates species not found.

The critical ecosystem services mangroves provide are increasingly at risk due to the decline in their spatial coverage and species populations across various global regions. Currently, 22 of the 70 recognized mangrove species (16%) are listed on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Recent studies underscore the necessity of assessing mangrove species composition and their ecological functions for effective conservation and management strategies. For example, research has emphasized the importance of precise species identification to inform restoration initiatives, especially in climate change and habitat degradation. These insights are crucial for preserving mangrove ecosystems' structural and functional integrity (Akram et al. 2023).

Among the four primary mangrove regions in Lampung Province, the Pesawaran is distinctive. It represents the south coast of Lampung, featuring a sinuous coastline and small river estuaries along the Sunda Strait. In contrast, the other three regions—Lampung Timur, Lampung Selatan, and Tulang Bawang—are situated along the east coast, where large rivers contribute silt to form gently sloping beaches. The east coast benefits from ample fresh water and sediment, creating an optimal environment for mangrove proliferation. This results in a crucial coastal and estuarine ecosystem enriched by terrestrial nutrients and sediments (Bunting et al. 2018). Mangrove ecosystems are open environments where very significant relationships occur between land (lithosphere and hydrosphere), estuaries (physiography of basins), and oceans and atmospheric systems (climate). Alluvial conditions and sediments from estuaries are sensitive indicators of allogeneic processes such as climate, tectonics, and floor level changes. Mangroves actively respond to natural processes in coastal areas, including sediment input, which influences their growth and distribution (Mazda and Wolanski 2023)

Although the Pesawaran region does not receive as much fresh water and silt substrate as the other regions in Pesisir Timur, it turns out that the Pesawaran region has the same high diversity index as the East Lampung region and is even better than the South Lampung and Tulang Bawang region (**Table 2**). It proves that human activity is the main factor in the loss of mangroves due to deforestation and anthropogenic pollution (Ilman et al. 2016). These human activities include activities related to land use for livelihoods such as industry, housing, and aquaculture. The east coast of Lampung is a center for aquaculture, where most of the mangrove forests have been converted into ponds. The phenomenon caused the east coast of Lampung to lose many mangrove species due to massive land conversion. Deforestation has reduced species diversity, density, and environmental service functions (Nordhaus et al. 2019). The aquaculture industry has been held responsible for the deforestation of mangrove forests in Southeast Asia over the last 30 years (Basha 2018), whereby Indonesia has lost around 600,000 ha of mangrove forests to shrimp ponds (Ilman et al. 2016).

Table 2. Mangrove diversity index on the coastal areas in Lampung

No	Area	Diversity Index (H')	Category
1	Pesawaran	1.9312	medium
2	Lampung Timur	1.9580	medium
3	Tulang Bawang	1.2402	medium
4	Lampung Selatan	0.9003	low

As a Southeast Asian region recognized as the global epicenter of mangrove biodiversity, the mangrove diversity index in Lampung coastal areas is relatively low. Mangrove forests in Kalimantan, Indonesia, typically exhibit H' values ranging from 2.8 to 3.5 (Murdiyarso et al. 2015). This condition is likely attributed to the higher anthropogenic pressures and unsustainable land-use practices in the coastal area of Lampung. Moreover, the species diversity of mangrove associates in south coastal region was higher than in the east coastal region. Mangrove associates are species often found in mangrove environments but not exclusively in estuarine areas because they can also be found outside mangroves (Giesen et al. 2006). The low diversity of associated mangrove species on the east coast indicates that damage to mangrove forests has occurred in the inland mangrove zone, where mangrove associations are generally found. As reported by Samaya et al. (2014), during the period 1994–2004, the area of mangrove forests in Labuhan Maringgai and Pasir Sakti, East Lampung has decreased by 14.79% and 92.8%, respectively, due to the massive conversion of coastal lands into shrimp ponds. This land use change has resulted in the loss of many types of mangroves because the terrestrial mangrove zone has a higher species richness than other zones (Pariwono 1999). Mangrove ecosystems are unsTable because they are easily damaged and difficult to recover. Mangroves are sensitive to many changes in their habitat caused by natural or anthropogenic activities, including aquaculture and deforestation (Goldberg et al. 2020; Yudha et al. 2022).

3.2. The Use of Mangroves as Medicinal Plants

Mangrove plants are still used as medicinal plants by the coastal communities in Lampung. The existence of people who still use mangrove plants as herbal medicine indicates that the practices and pieces of knowledge are still in the community, which means it has the potential to be preserved. However, among users of mangrove plants as medicine in the Lampung coastal region, 59% were over 41 years, 34% were 31–40 years, and only 7% were under 30 years. It illustrates that the use of mangroves as medicinal plants is no longer widespread and is increasingly being abandoned by the younger generation. It indicates that there has been an erosion of traditional knowledge and shows the vulnerability to the loss of the culture of traditional medicine in society. As stated by Hedges et al. (2020), the knowledge of rural communities and indigenous peoples about using plants for medicinal purposes tends to decrease globally. The same condition was reported by Lawrence et al. (2014), that the younger generation in Central Uganda has less interest in using medicinal plants than the older generation. As Weckmüller (2019) reported in the Waorani Region of Ecuador, the older generation tends to have better knowledge about medicinal plants than the younger ones. The primary factors contributing to the erosion of ethnopharmacological knowledge among younger generations are globalization, urbanization, and a lack of ethnopharmacological education. Globalization and modernization have shifted traditional cultural values, including traditional medicine practices, towards more widely accepted modern healthcare practices (Quave 2021). Urbanization has driven the migration of young people from rural to urban areas, where they have less interaction with the natural environment and traditional communities that practice ethnopharmacology (Arjona-García 2021). Moreover, the decline in traditional knowledge is exacerbated by the insufficient incorporation of its significance into formal educational curricula and informal family teachings (Athayde et al. 2017).

Most of those who use mangrove plants for medicinal purposes are male (61%), with females representing only 39%. This indicates that men in the communities have a stronger connection to mangroves, likely due to their roles as fishermen who frequently engage with the sea and mangrove ecosystems. This observation contrasts with findings from other studies on the relationship between gender and medicinal plant knowledge in terrestrial settings. For example, Rodrigues and Oliveira (2020) note that in many parts of the world, women generally hold more extensive knowledge of medicinal plants than men, reflecting their responsibilities in managing family health and traditional medicinal practices. Additionally, d'Avigdor et al. (2020) found that in the Fiche region of Ethiopia, women possess greater expertise in herbal medicine than men, particularly regarding the use of medicinal plants within the household.

The utilization of mangroves as medicinal plants is most common among low-income individuals, based on the criteria of the Central Statistics Agency of the Republic of Indonesia. These individuals typically earn between USD 100–167 per month (54%), with those in the moderate-income bracket earning USD 168–233 per month (26%) and high-income earners exceeding USD 233 per month (20%). The limited purchasing power of low-income groups necessitates reliance on accessible and inexpensive resources, leading them to favor medicinal plants for their affordability and availability. The preference for herbal remedies is often driven by their ease of access, low cost, cultural acceptance, and the limited availability of hospital or medical services (Rutemberwa et al. 2013). Conversely, higher-income individuals who continue to use medicinal plants primarily do so due to their perceived effectiveness and the lower incidence of side effects compared to synthetic drugs. As Fu et al. (2021) noted, the preference for herbal medicine is largely influenced by the belief in its high efficacy and reduced side effects relative to synthetic pharmaceuticals. This confidence in the therapeutic potential of herbs is further bolstered by historical and cultural traditions that advocate using medicinal plants as effective treatments for various health problems.

In terms of ethnicity, the majority of users of mangrove plants for herbal medicine are Javanese (55%), followed by Bugis (14%), Minang (9%), Sundanese (7%), Lampungnese (7%), and others (8%). The predominance of Javanese users can be attributed to the fact that the Javanese constitute the largest ethnic group in Lampung Province. According to data from BPS Provinsi Lampung (2020), the five major ethnic groups in Lampung Province are Javanese (64.17%), Lampungnese (13.56%), Sundanese (11.88%), Malay (5.64%) and Balinese (1.38%). Another reason is that Javanese people have a tradition of using medicinal plants known as "jamu" for generations, as Woerdenbag and Kayser (2014) reported that the Javanese people have been using and practicing traditional herbal ingredients for centuries ago. For the Javanese, herbal medicine is used not only to cure the disease but also for other purposes, such as health care, tonics and health drinks, beauty treatments, and enhancing immunity and protecting the body. The exciting thing is that even though the Bugis are a minority in tribe percentage, they have a significant percentage of using mangrove plants as medicine. Presumably, it is because the Bugis are known to have a culture very close to the sea. Therefore, their interaction and understanding of mangroves are better than other tribes. Bugis is known as a skilled and reliable fisherman and sea explorer. They have developed excellent skills in catching fish and exploiting other marine resources (Metalisa et al. 2022).

The use of mangroves as medicinal plants in Lampung coastal areas varies significantly across different regions, with differences arising from the specific plant species utilized and the medicinal properties believed by the local communities. **Table 3** compares the use of mangroves as medicinal plants across these regions. Among the 28 mangrove species identified in Lampung coastal areas, only seven true mangrove species and one associated mangrove species have been employed by the local population for medicinal purposes. This indicates a vast untapped potential for utilizing mangroves as sources of medicinal plants. Mangroves are known to produce various secondary metabolites crucial in the pharmaceutical industry. Chen et al. (2022) reported the isolation of 1,387 new metabolic products from mangrove-associated fungi over the past three decades (1989–2020). Among the eight species used by the community, 10 specific medicinal benefits have been identified, including antiseptic (anti-bacterial), treatment for rheumatoid arthritis, antioxidant (anticancer), antihistamine, antipyretic, anti-inflammatory, anti-cholesterol, and antihypertensive properties. This is a broader range of applications than previously reported by Genilar et al. (2021), who noted that various mangrove tissue extracts possess properties such as anticancer, anti-tumor, anti-inflammatory, anti-viral, anti-fungal, anti-bacterial, and antidiabetic effects. These findings emphasize the richness of local wisdom and traditional knowledge, highlighting the need for further research to advance scientific understanding. Despite the scientific validation of medicinal properties in mangroves, coastal communities in Lampung have not yet harnessed mangrove plants for anti-tumor, anti-viral, anti-fungal, and antidiabetic purposes (Genilar et al. 2021). Several mangrove species along the Lampung coastal areas are known to possess these properties, including anti-tumor activity (*C. tagal* and *R. apiculata*), anti-viral effects

(*A. ilicifolius, A. marina, R. apiculata,* and *R. mucronata*), anti-fungal properties (*A. marina*), antidiabetic benefits (*A. ilicifolius* and *B. gymnorrhiza*), and anti-fertility (*A. marina*) (Rodiani et al. 2023). This underscores the need to enhance public awareness regarding using mangrove plants as herbal medicines, enabling coastal communities to realize the full potential health benefits that mangroves offer.

Table 3. Comparison of the use of mangroves as medicinal plants in each region in Lampung Province

Area	Main Ethnic	Species	Part of plant	Efficacy
Pesawaran	Bugis 63%, Sundanese 25%, Javanese 13%	*A. alba*	leaf	Wound medicine/antiseptic
		A. ilicifolius	fruit	Ulcer medicine
		R. apiculata	fruit	Wounds medicine /antiseptics, stomach aches medicine/analgesic
		R. stylosa	leaf	Wound medicine/antiseptic
			fruit	Anti-rheumatism
			bark	Wound medicine/antiseptic
Lampung Timur	Javanese 60%, Minang 30, Bugis 7%	*A. marina*	leaf	Wound medicine/antiseptic and source of vitamin
			fruit	Anti Allergy/antihistamines
		A. ilicifolius	leaf	Anti-rheumatism and muscle aches medicine/analgesic
		R. apiculata	leaf	Antipyretic
		R. mucronata	root	Increase stamina/vitality
		S. caseolaris	fruit	Anti-cholesterol antioxidant
Tulang Bawang	Javanese 54%, Lampungnese 23%, Malay 23%	*A. ilicifolius*	leaf	Anti-cholesterol increased stamina/vitality
		R. stylosa	leaf	Anti-rheumatism
		S. caseolaris	leaf	Antipyretic
			fruit	Antioxidant, anti-rheumatism, and muscle ache medicine/analgesic, antipyretic, anti-hipper tension
Lampung Selatan	Javanese 78% Sundanese 22%	*A. marina*	leaf	Fever reliever/antipyretic
			fruit	Anti-rheumatism and muscle aches medicine/analgesic.
		R. apiculata	fruit	Anti cholesterol
		R. stylosa	leaf	Wound medicine/antiseptic, anti-allergy/antihistamine/, anti-cholesterol, anti-Rheumatism and fever reliever/antipyretic
		T. catappa	leaf	Internal disease medicine

On the other hand, coastal communities in Lampung traditionally have proven the efficacy of mangrove plants as anti-rheumatoid arthritis (*R. stylosa*, *A. ilicifolius*, *S. caseolaris* and *A. marina*); antihistamine (*A. marina* and *R. stylosa*); antipyretic (*R. apiculate*, *S. caseolaris* and *R. stylosa*); anti-cholesterol (*S. caseolaris*, *A. ilicifolius*, *R. apiculate* and *R. stylosa*); antihypertensive (*S. caseolaris*); as well as vitamins and stamina enhancers (*A. marina*, *R. mucronata* and *A. ilicifolius*). These six properties are very interesting for further scientific study to find new sources of medicine. Often, new sources of medicinal ingredients are found based on local wisdom that the community has practiced for generations.

Coastal communities in Lampung utilize true mangroves as medicinal plants (**Table 2**) and associate species such as *Terminalia catappa*. This species, however, is only employed medicinally in Lampung Selatan despite its presence throughout the Lampung coastal region (**Table 1**). Notably, residents of Lampung Selatan use *T. catappa* empirically to treat internal diseases, a practice supported by scientific research. Anand et al. (2015) highlight the potential of *T. catappa* as a medicinal plant due to its rich bioactive constituents, including phenols, flavonoids, and carotenoids. Pharmacological studies have substantiated the plant's efficacy in various therapeutic roles, including antimicrobial, anti-inflammatory, antidiabetic, antioxidant, hepatoprotective, and anticancer activities (Anand et al. 2015). The plant's extensive potential as a source of herbal medicine is underscored by the presence of bioactive compounds across all its tissues—leaves, fruit, seeds, and stem bark (Divya et al. 2004).

Interestingly, the study findings reveal that the same plant species are employed for various purposes across different regions (**Table 3**). Even more striking is the lack of a significant correlation between the uses of a species and ethnic groups. This suggests that the same ethnic group does not consistently use the same plant species for treating identical ailments. Such variability indicates that the available knowledge, information, and cultural acculturation profoundly influence the community's practical experience with medicinal plants. The interplay of these factors fosters new forms of local wisdom shaped by regional contexts. According to Royani and Rahayu (2021), local wisdom emerges from a learning process based on individuals' perceptions of knowledge and information adapted to local environmental conditions. Consequently, local wisdom is dynamic and evolves, becoming more comprehensive and diverse due to cultural interactions and the flow of information within the community.

3.3. Species Use Value (SUV)

Species use value (SUV) indicates the value of a medicinal plant species used by the community in a region. The use value of mangrove plant species as medicinal resources in the Lampung coastal region is illustrated in **Fig. 2.** Notably, *S. caseolaris* emerges as the species with the highest medicinal use value on the Lampung coastal region. This is unexpected, given its limited distribution compared to the Rhizophora genus, which is prevalent across all mangrove centers. *S. caseolaris* is found only in Tulang Bawang and Lampung Selatan. The high use value of *S. caseolaris* is likely linked to the popularity of its fruit (pidada), a favored edible mangrove fruit among the local communities. In Indonesia, at least nine mangrove species produce edible fruits, widely consumed by the population. These include *A. marina, A. alba, B. gymnorrhiza, S. alba*, *S. caseolaris*, *N. fruticans*, *R. mucronata*, *R. apiculata*, and *R. stylosa* (Farhaeni 2016). Among these, pidada is particularly popular due to its soft texture, distinct and delicious taste, and versatility in being processed into various food and beverage products (Abeywickrama and Jayasooriya 2010). Additionally, pidada fruit is known for its pleasant aroma, non-toxic nature, and suitability for immediate consumption (Alharanu and Eviana 2020).

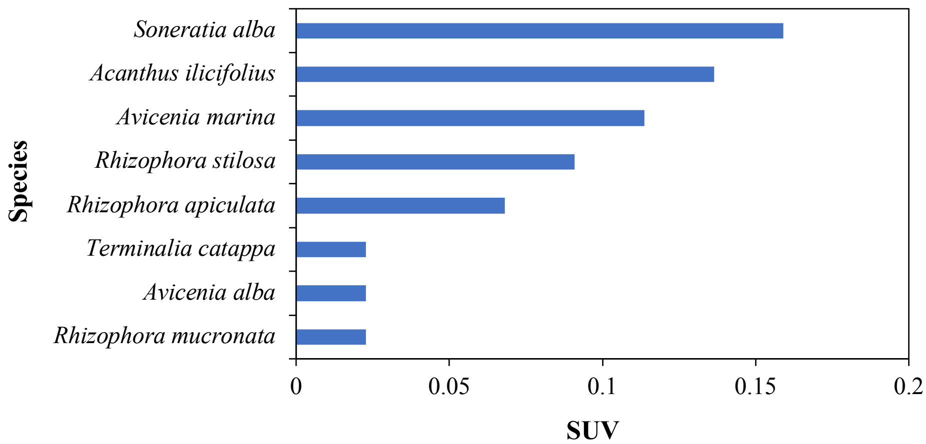

Fig. 2. Species use a value of mangrove plant in the Lampung coastal region.

The high species use value of *S. caseolaris* indicates that the community empirically recognized and utilized many of its benefits. This aligns with the findings of Nufus et al. (2023), who identified at least 24 phytochemical components in *S. caseolaris*. These include nine triterpenes, eight steroids, and three flavonoids, which function as antioxidants, neutralizing free radicals and helping to prevent diseases such as cancer. They effectively expel viruses and diarrhea, help avoid thrombus formation, prevent atherosclerosis, act as allergy deterrents, and include four carboxyl and benzene derivatives, which are highly valuable as antioxidants and antimicrobial agents in the forms of alkaloids, flavonoids, saponins, tannins, and phenolics. The combination of taste and health benefits makes *S. caseolaris* a species with the highest use value as a medicinal plant on the Lampung coastal region. This is understandable, as herbal medicines with antioxidant and antimicrobial properties are crucial for developing countries like Indonesia, where infectious diseases remain a leading cause of mortality (Simlai et al. 2014).

3.4. Plant Part Value (PPV)

The Plant Part Value (PPV) is a crucial metric for identifying the most commonly used plant parts in medicinal applications. Different plant parts exhibit varying capacities to accumulate secondary metabolites, which makes them particularly interesting for research. Each plant part is a unique "factory", producing and offering substantial pharmaceutical potential (Jiang et al. 2013). The study results revealed that in Lampung coastal region, leaves are the most frequently utilized plant part for medicinal purposes, followed by fruit and roots, as depicted in **Fig. 3**.

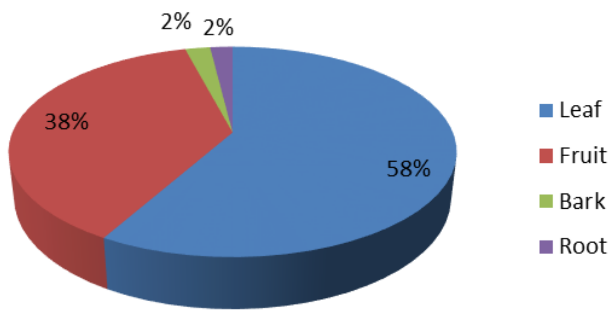

Fig. 3. Plant part value of mangrove plants as medicine in the Lampung coastal region.

Leaves are the most commonly used plant part for medicinal purposes in Indonesia (Supiandi et al. 2019). The high plant part value (PPV) of leaves is likely due to the high concentration of this part and the diversity of secondary metabolites. Zahoor et al. (2017) noted that numerous studies have demonstrated the presence of secondary metabolites in leaves. Furthermore, Anugrah et al. (2022) attribute the dominance of leaves in medicinal use to their ease of harvesting, regrowth potential, and year-round availability. The elevated PPV of leaves is also linked to the relative ease of phytochemical extraction compared to other plant parts. Mulyani et al. (2020) observed that the leaves extraction process is simpler. Additionally, the high PPV of leaves is related to plant conservation, as leaf harvesting poses minimal risk to plant survival. Extracting leaf biomass within sustainable limits generally does not significantly disrupt plant life, unlike harvesting stems, roots, or bark, which can jeopardize the plant's survival (Miswadi et al. 2017).

The results of this study have not shown the utilization of mangrove plant stems as medicine. The stem part is less attractive because harvesting and extracting its phytochemicals is more complex than other parts. Furthermore, the removal of stem parts in significant quantities also has the potential to cause damage and threaten the survival of mangrove plants. However, the possibility of mangrove plant stems as medicinal ingredients is interesting to study because plant stems, especially heartwood, contain several extractive substances that have the potential to be bioactive. Wood extractives possess significant quantities of these compounds, with certain extractives exhibiting substantial antioxidant and antimicrobial properties, thus supporting their application as preservatives (Santos et al. 2022). Naturally, extractive substances in wood protect wood against fungi and termites, so their presence increases wood's durability (Kirker et al. 2012). The results also showed that different parts of the plant from the same species were used to treat other diseases; for example, *A. marina* leaves were used as a wound medicine/antiseptic, while the fruit was used as a wound medicine/antiseptic and an antihistamine. This indicates the potential for differences in the types and concentrations of phytochemicals in each part of the plant, which are of interest for further study. The types and concentrations of bioactive compounds contained in a plant species may differ in each tissue. As stated by Lakshmaiah et al. (2022), specific plant tissue has the potential to produce different types and concentrations of bioactive from other tissue in the same plant.

3.5. Fidelity Level (FL)

Fidelity Level describes the level of public confidence in an area towards the efficacy of treatment or healing of a disease using a particular material or species. The Fidelity Level (FL) of various mangrove plant species used for medicinal purposes along the Lampung Coast is generally quite low, as shown in **Table 4.** This low FL value contrasts sharply with findings from other studies on medicinal plant use in Indonesia. For example, Riadi et al. (2019) found that 16 out of 40 plant species utilized by the Dayak Kanayatn had FL values reaching 100%. Similarly, Yusro et al. (2020) reported that eight medicinal plants used by the North Kayong community in South Kalimantan also had an FL value of 100%. A high FL value typically indicates the presence of valuable phytochemical compounds within a plant, which warrants further investigation for potential pharmacological applications (Caunca and Balinado 2021).

Mangrove plants are used as herbal medicines on the Lampung coastal areas and generally have low FL values. Low FL values indicate a common preference for mangrove plant species to treat certain diseases. The low FL value does not entirely mean that mangrove plants are ineffective in treating a disease. A low FL value implies that because of the very diverse phytochemical content, this plant is believed to treat many diseases; therefore, if the FL value is calculated for one disease species, the results may be low. Caunca and Balinando (2021) state that the low FL value for one type of disease may be because this plant is used to treat many diseases. Most of the mangrove plants used as medicine in the Lampung coastal region are believed to have more than one benefit, such as *A. marina* and *R. apiculata* (4 properties), *A. ilicifolius* and *R. stylosa* (5 properties), and *S. caseolaris* (6 properties). Plants that have many therapeutic applications indicate the presence of various potent phytochemicals.

Table 4. Fidelity level of the use of mangroves in the Lampung coastal region

Species	Efficacy	Fidelity level
Avicennia alba	Wound medicine/antiseptic	2%
	Stomach aches medicine	2%
Avicennia marina	Source of vitamin	2%
	Wound medicine/antiseptic	2%
	Anti allergy/antihistamines	2%
	Anti-rheumatism and muscle aches medicine	5%
	Fever reliever/antipyretic	2%
Acanthus ilicifolius	Fever reliever/antipyretic	9%
	Anti-hypertension	5%
	Anti-rheumatism and muscle aches medicine	5%
	Ulcer medicine	2%
	Anti-cholesterol	5%
	Increase stamina/vitality	2%
Terminalia catappa	Internal disease medicine	2%
Rhizophora apiculata	Wound medicine/antiseptic	14%
	Stomach aches medicine	2%
	Fever reliever/antipyretic	5%
	Anti-cholesterol	2%
Rhizophora mucronata	Increase stamina/vitality	5%
Rhizophora stylosa	Wound medicine/antiseptic	7%
	Fever reliever/antipyretic	5%
	Anti-cholesterol	5%
	Anti allergy/antihistamines	2%
	Anti-rheumatism and muscle aches medicine	9%
Sonneratia caseolaris	Anti-cholesterol and antioxidant	9%
	Antioxidant	14%
	Anti-cholesterol	7%
	Wound medicine/antiseptic	2%
	Fever reliever/antipyretic	9%
	Anti-rheumatism and muscle aches medicine	7%
Average		5%

4. Conclusions

The mangrove forests along the Lampung coastal region comprise 28 species from 15 families. The species diversity of mangroves in the four mangrove center regions of Lampung Province is classified as moderate, with H' values ranging from 0.90 (South Lampung) to 1.95 (Pesawaran). These values are relatively lower than the average H' values for mangroves in Sumatra and Kalimantan, which range from 2.8 to 3.5. Ethnopharmacological practices involving mangrove plants remain an integral part of the coastal culture in Lampung. However, only a small portion (5.33%) of mangrove species are utilized ethnopharmacologically to prevent and treat diseases. From an ethnopharmacological perspective, mangroves provide ten benefits, including antiseptic, treatment for rheumatoid arthritis, antioxidant, antihistamine, antipyretic, anti-inflammatory, anti-cholesterol, and antihypertensive properties. Nevertheless, the fidelity level in utilizing mangroves as medicinal plants is relatively low. Among the mangrove plants, *Sonneratia caseolaris* is frequently used as a medicinal plant, with a species use value of 0.1591. The leaf is the most commonly used plant part in the medicinal application of mangrove plants, with a plant part value of 58%. Interestingly, a single species may be used for different purposes across different areas, and there is no clear correlation between ethnicity and the form of utilization of mangrove plants as medicine. However, this study has found essential things, namely six properties of mangroves as herbal medicine, which are believed and practiced by the community as local wisdom but have not been studied scientifically. This finding could be the basis for scientific studies to find new sources of medicine.

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