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Ecological and Potential Ethnobotanical Characterization of Mangrove Ecotourism Area Sungai Bersejarah, Siak Regency, Riau, Indonesia

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ABSTRACT

This study examined the potential of mangrove ecotourism in Siak District, Indonesia, as an ethnobotanical research center that integrates traditional medicinal plant use with environmental preservation. Through field studies that included environmental quality monitoring, vegetation and fauna identification, and interviews with local communities, this study showed that the area has high biodiversity and potential for ethnobotanical development. There were 11 mangrove species and 28 faunal species, including protected and endangered species. In addition to being ecotourism objects, mangroves have also been identified as a potential source of traditional medicinal plants, with seven species being utilized by the local community. The various phytochemical components of mangroves provide a wide range of therapeutic effects, including antibacterial, antioxidant, and antitumor effects. Accordingly, the Sungai Bersejarah Siak mangrove ecotourism area promises sustainable development that integrates aspects of environmental conservation, tourist attractions, and the utilization of ethnobotanical potential to improve public health.

1. INTRODUCTION

Mangroves are a group of vegetation that grows in coastal areas of tidal zones [1, 2]. This vegetation consists of various plant species that can live in extreme environments such as tides, high salinity, and muddy soil [3]. Mangroves play an important role in maintaining coastal ecosystem balance. The main functions of mangroves are to protect the coast from abrasion and storms, provide breeding grounds for various species of fish and invertebrates, maintain water quality by absorbing excess nutrients and pollutants [4], and act as a source of medicinal plants [5-7].

Riau Province is known to be an area rich in biodiversity, including mangrove species. The mangrove area in Riau Province is 213,459.21 ha [8], making Riau the third-largest mangrove area in Indonesia. The distribution of mangroves in Riau Province covers various habitats, including coastlines [9], estuaries [10], and rivers [11]. Mangroves in Riau Province are spread across seven coastal districts and cities based on administration, one of which is the Siak Regency with an area of 6,820.53 ha [12].

Local communities in the Siak District utilize mangroves as firewood, charcoal, nipa roofing material, fishing locations, shrimp, crabs, shellfish [13], and medicinal plants [14]. Some common mangrove species in Siak District include *Rhizophora apiculata, Avicennia alba, Sonneratia ovata, Rhizophora mucronata, Xylocarpus granatum,* and *Bruguiera gymnorrhiza* [15]. The diversity of these species reflects their environmental dynamics and provides a great opportunity to understand the potential of mangrove plants as sources of traditional medicine. Environmental conditions affect the diversity of mangrove vegetation types and associated fauna in ecosystems. Different mangrove species have different chemical characteristics, the understanding of which can be the basis for the development of medicines, especially traditional medicines. Approximately 27 mangrove species have been used in traditional medicine [16].

Traditional communities in mangrove ecosystems have long used mangrove plants for medicinal purposes. Mangroves are the richest source of phytochemicals, with important chemical compounds, such as carbohydrates, alcohols, amino acids, various types of fats, fatty acids, lipids, phenolic compounds, steroids, glycosides, and triterpenes [17]. Mangrove vegetation is rich in steroids, saponins, flavonoids, alkaloids, and tannins [16]. These products are primary metabolic compounds that are essential for the maintenance of life processes as well as secondary metabolic substances that play important roles in toxicology, pharmacology, and ecology. Mangrove plants have been shown to have anticancer, antitumor, anti-inflammatory, antiviral, antifungal, antimicrobial, and antidiabetic properties [18]. Efforts should be made to document the ecological characteristics and ethnobotanical potential of mangrove areas to increase local knowledge in line with environmental conservation and to improve the health and welfare of the community.

Ethnobotany studies the relationship between plants and society, both on a local and global scale [19]. Ethnobotanical research has a dual purpose: preserving traditional knowledge

that is beneficial to humans and the environment and protecting plant species that are utilized [20]. Ethnobotany studies the interaction between local communities and their natural environment, including the knowledge of plant natural resources [21]. Consequently, ethnobotany has great potential for revealing the traditional knowledge system of a community or ethnic group in terms of biodiversity, conservation, and cultural aspects.

Mangroves provide an ideal environment for various fauna and medicinal plants and have demonstrated significant pharmacological potential [18]. Recent studies have highlighted the ethnobotanical potential of mangroves, particularly focusing on their medicinal properties and nutritional value. A study that explored 34 plant species from 18 mangrove families in Sundarbans, West Bengal, India revealed substantial pharmacological potential [22]. Additionally, research on the nutrient content and bioactive compounds in the fruits and leaves of 16 species from 11 mangrove families in the Western Mekong Delta, Vietnam, has shown promising potential for use in both food and medicine [23]. In South Sumatra, Indonesia, local communities have traditionally used mangrove plants as a source of medicine, utilizing 250 plant species from 79 families for traditional medicine [24]. Further exploration of mangrove vegetation could potentially lead to the discovery of new plant species that can be developed as sources of food and medicine, while maintaining sustainability to protect natural plant abundance.

Ethnobotanical knowledge significantly influences sustainable management practices and the conservation of mangrove ecosystems [25]. This local knowledge helps identify plant species with medicinal value that can be harvested and managed sustainably. By understanding how communities utilize and manage mangrove resources, conservation strategies can be designed to protect biodiversity, while supporting local livelihoods. Further research and sustainable conservation approaches can transform mangrove ecotourism areas into centers for research and development by exploring the medicinal potential of mangrove plants. This not only enhances the ecotourism value of these areas but also contributes significantly to natural pharmacies and global public health.

Mangrove ecotourism has provided a significant focus on tourist attractions and environmental conservation. However, minimal efforts have been made to develop education and understand the potential of mangrove plants as valuable medicinal resources for improving public health. This study was conducted in an ecotourism area of the Siak Regency, Riau, Indonesia, to evaluate the ecological characteristics and identify the ethnobotanical potential of mangrove forests using field-inventory techniques. Through this approach, we aimed to describe the ecological conditions and valuable local knowledge of the traditional use of different mangrove plant species in medicine, thus enabling the development of sustainable and affordable health solutions for communities living in mangrove areas.

2. RESEARCH METHODS

2.1 Study area

This study was conducted from February to July 2023 in the Sungai Bersejarah mangrove ecotourism area of Kayu Ara Permai Village, Sungai Apit District, Siak Regency, Riau, Indonesia. Since 2018, this area has been managed by a community organization engaged in mangroves, namely, the Laskar Mandiri Conservation Group formed by the people of Kayu Ara Permai Village. This organization manages the mangrove forest as an educational tourism center and conducts conservation efforts. Geographically, the research site is located at latitude 1°07' 02.2″ N and longitude 102°11' 34.2″ E in the Siak River Basin, with a sloping beach facing Tebing Tinggi Island and Padang Island, Bengkalis Regency, as shown in Figure 1.

According to Government Regulation Number 50 of 2011, the Siak Regency is designated as a national tourism development area (KPPN) in Riau Province, with the development of natural tourism, especially mangrove ecotourism, as a flagship program. The mangrove area on the coast of the Sungai Apit District is one of the regional development areas in the context of utilizing space for regional tourism activities following the policies of the Siak District Government. This area is one of the potential areas to be developed as an ecotourism object because it has a relatively stable biodiversity and is still well maintained. The management of this area involves the participation of the local communities. Since 2017, this area has been designated an educational area protected by students and environmental activists. Thus, this area has great potential to study the ethnobotanical and ecological characteristics of mangrove forests.

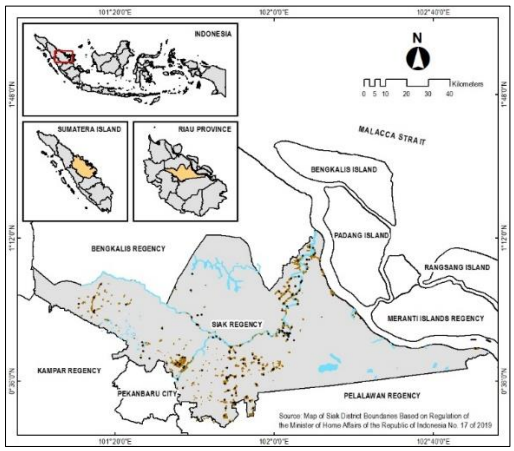


Figure 1. Siak Regency map, Riau, Indonesia

2.2 Data collection

Before collecting field data, a survey was conducted to identify the proposed locations. Routes and observation points were determined based on the ecological representation, accessibility, and presence of local communities utilizing the mangrove forest at the three research stations (Figure 2). Ecological representation ensured that the various ecological zones of the mangrove forest, from tide-exposed coastal areas to more stable inland areas, provided an overview of vegetation species diversity, forest structure, and ecological conditions in these zones. Accessibility was considered when selecting observation points that were easy to reach, allowing researchers to collect data efficiently and safely, particularly in challenging terrain or unpredictable weather conditions. The presence of local communities was also considered, as they provide valuable traditional knowledge and ensure that research stations align with existing utilization practices.

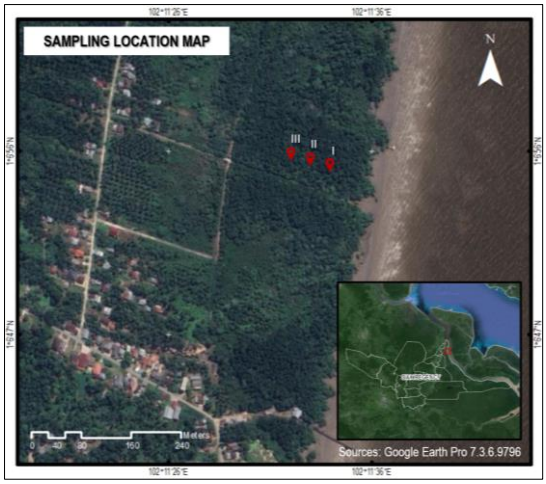


Figure 2. Map of Sungai Bersejarah Siak mangrove sampling location

This research method focuses on collecting information and data through various means including observations, surveys, literature reviews, and personal interviews with local communities. Sampling procedures employed a multifaceted approach to comprehensively cover data on vegetation, environmental quality, fauna, and ethnobotanical knowledge.

Data on plant species, fauna, and environmental quality were collected through field observations using a combination of transect and plot methods [19]. Transects divided the mangrove ecosystem into different zones based on water depth, salinity, and tidal influence. Mangrove species and density data were obtained from plots measuring 20 × 20 m (tree level), 10 × 10 m (pole level), 5 × 5 m (sapling level), and 2 × 2 m (seedlings, lianas, and other understory levels). Three test plots were established in each transect, with a distance of 25 m between them, and arranged systematically. Transects extend from the coast perpendicularly inland, traversing the mangrove community from the foremost formation (offshore) to the rearmost formation bordering the mainland [26]. An illustration of the observation plot layout is shown in Figure 3.

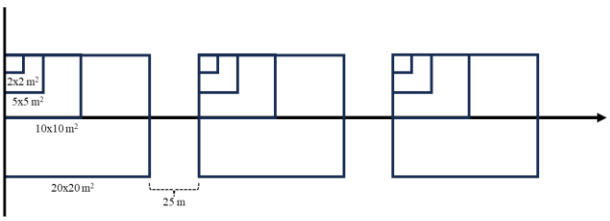


Figure 3. Diagram of transects and observation plots used at the study site

Vegetation sampling involved identifying and recording plant data at the tree level, including species name, number of individuals, diameter at breast height (DBH) (±1.3 m), and basal area [27]. For the pole, sapling, and seedling levels, data on species names and the number of individuals per species were collected to represent the various vegetation layers throughout the mangrove forest thoroughly.

Environmental quality was assessed in situ using various instruments. Soil and water temperatures were recorded with a thermometer, soil, and water pH levels were measured with a pH meter, and salinity was determined using a refractometer or salinometer [28]. The substrate type was evaluated through visual inspection and sediment analysis [29]. Measurements were repeated thrice to provide a comprehensive representation of the environmental conditions of the mangrove ecosystem [30].

Faunal data were collected in situ using a visual recording method with a camera [31]. This method involves the direct observation of visually detectable fauna in mangrove areas. Cameras were strategically placed to capture images and videos of animal activity, providing valuable information on the presence of the species. The use of camera traps and video recordings facilitates the non-invasive observation of mammals, reptiles, birds, and fish at the study site.

Ethnobotanical information was collected through a survey using semi-structured interviews with local community members based on a research questionnaire designed to assess their knowledge about the use of mangrove plants as medicine. The respondents were selected using purposive and snowball sampling methods [32], focusing on individuals living around the Sungai Bersejarah mangrove ecotourism area. During the interviews, direct observations of the plant parts used as medicine were made, and researchers actively participated in community activities related to the medicinal use of mangrove plant parts.

Interviews were conducted with 42 respondents from the research site. The information collected included gender, age, education level, social/occupational status, knowledge of mangrove species used as medicinal plants, parts of the plants utilized, processing and utilization methods, content, and functions and uses of these plants. The respondents included local community members, both men and women, from three different age groups 25-45 years, 46-65 years, and over 65 years [33]. The study also included key informants such as shamans/traditional healers, community elders, local medicinal plant users, and government officials and representatives from relevant agencies. Participants' characteristics are presented in Table 1.

Table 1. Socio-demographic characteristics of respondents

No.	Variable	Level	Frequency	Percentage
1.	Gender	Women	27	64.29
		Men	15	35.71
2.	Age (in years)	25-45	24	57.14
		46-65	15	35.71
		>65	3	7.14
3.	Education	Primary	7	16.67
		Secondary	25	59.52
		University	10	23.81
4.	Social status/ occupation	Shamans	4	9.52
		Elders	4	9.52
		Users	34	80.95

Source: Author's survey data, 2023

The respondents in this study ranged in age from 25-70 years, aligning with the opinion of Voeks [34], which suggests that knowledge tends to increase with age. The sample comprised 27 women (64.29%) and 15 men (35.71%). Gender was considered in the selection of informants because several publications have concluded that men are generally more familiar with mangrove resources, particularly building materials and wood collection for public use [20]. However, women tend to have a broader understanding of medicinal plants than men [35], likely due to their role in family healthcare. As a result, most informants were women. Most respondents had a secondary education level, completed high school, or an equivalent. Individuals with secondary education

typically have a broad general knowledge base, allowing them to express their thoughts and opinions clearly, although they may be limited in their mastery of more specific terminology or concepts [36].

2.3 Data analysis

Data analysis was performed using quantitative and qualitative methods. Quantitative analysis focused on observational data regarding mangrove ecological characteristics, including mangrove vegetation data (type, density, and cover) and environmental quality data (soil temperature, water temperature, soil pH, water pH, water salinity, and substrate). Mangrove species were identified using the mangrove identification book of Malik et al. [27]. Mangrove cover data was obtained using a recent method involving hemispherical photography [29]. Species density (Di) was calculated using the equation of Bengen et al. [37], which involves calculating the number of species stands (Ni) per unit area (A). This study also reported the classification of mangrove vegetation density referring to the Decree of the Minister of Environment Number 201 of 2004 concerning Standard Criteria and Guidelines for Determining Mangrove Damage [28]. This classification consists of sparse (<1,000 ind/ha), moderate (1,000-1,500 ind/ha), and dense (>1,500 ind/ha). Environmental quality observation data analysis, including soil temperature, water temperature, soil pH, water pH, water salinity, and substrate, was conducted using a descriptive statistical approach by calculating the averages of in-situ measurements.

The qualitative analysis involved data from observations of faunal species (mammals, reptiles, birds, and fish) and information obtained through an ethnobotanical survey of mangrove plants based on the respondents' knowledge, including scientific names, local names, phytochemical properties, parts or organs used, and medicinal uses. The species that were successfully documented were identified through a literature review. Species from the mammal, reptile, and bird groups were identified using the Indonesian flora and fauna dictionary [38], while validation of species in the fish group was identified using the search field on the website https://fishbase.de/ [39]. Protected fauna status refers to the International Union for Conservation of Nature (IUCN) assessment on the website https://www.iucnredlist.org/en [40]. Data on the ethnobotanical characteristics of mangroves collected from respondents were verified using scientific literature and Heyne's monumental book on useful Indonesian plants [41]. All research data were compiled and analyzed using Microsoft Excel software. The analysis results were then visualized in statistical distribution tables and discussed descriptively [42].

3. RESULT AND DISCUSSION

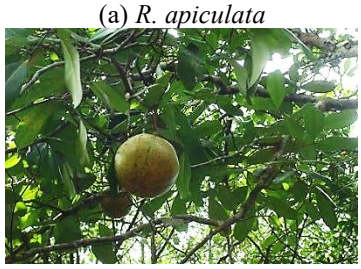
3.1 Ecological characteristics of the mangrove ecotourism area of the Sungai Bersejarah Siak

Sungai Bersejarah Siak ecotourism area displays rich ecological characteristics with potential biodiversity associated with various fauna. This area offers a variety of habitats, including mangrove forests, riparian forests, and river ecosystems, thus supporting the existence of various faunal species such as mammals, reptiles, birds, and fish, and forming a complex and dynamic ecological network. The results of vegetation identification showed that this area has diverse mangrove species, including 11 species distributed across eight families. Most of the mangrove species consist of the Rhizophoraceae family (4 species), followed by the Avicenniaceae, Rubiaceae, Meliaceae, Sonneratiaceae, Combretaceae, Euphorbiaceae, and Pteridaceae families, each of which has 1 species (Table 2). The number of mangrove vegetation types in this study was greater than the identification results for 2021, which included eight species [43]. In addition to indicating the dynamics and changes in the mangrove ecosystem, the increase in the number of vegetation types at the study site over the last three years also reflects the success of the restoration and conservation efforts in the Sungai Bersejarah Siak mangrove ecotourism area.

The observed area contained 40 ind/ha at the tree level, 66 ind/ha at the sapling level, and 209 ind/ha at the seedling level. Tree density tended to decrease as the growth strata increased. The gradual decrease in tree density from seedling strata to tree strata is due to natural selection and competition to obtain limited resources [44]. Overall, there were approximately 315 individual mangrove plants, with *R. apiculata* and *X. granatum* being dominant (Figure 4). *R. apiculata* species dominated at Station I with 76.73% cover, whereas *X. granatum* was evenly distributed at Stations II and III with 75.42% and 74.04% cover, respectively (Table 3). Hamid et al. [45] stated that the regeneration of *R. apiculate* vegetation in the study site was in a good category, making it the dominating species. Referring to the Decree of the Minister of Environment Number 201 of 2004 concerning the Standard Criteria and Guidelines for Determining Mangrove Damage, the level of mangrove density in the Sungai Bersejarah Siak ecotourism area is in the sparse category (<1,000 ind/ha).

The environmental conditions of the mangrove ecotourism area of the Sungai Bersejarah Siak are influenced by diurnal tides, with a substrate of muddy soil and muddy soil mixed with sand. The soil temperature ranges from to 26-27°C, while the water temperature reaches 30-31°C. Soil pH is around 6.0, while water pH ranges from 6.1-6.4, with water salinity in the range of 30-31‰. Environmental conditions support the growth of mangrove vegetation optimally [46-48]. The measurement results of the environmental quality parameters are presented in detail in Table 4.

(a) *R. apiculata*



(b) *X. granatum*

Figure 4. Dominant mangrove species in mangrove ecotourism area of Sungai Bersejarah Siak

Table 2. Species of mangroves found in the ecotourism area of Sungai Bersejarah Siak

No.	Family	Scientific Name	Local Name
1.	Verbenaceae	*Avicennia alba* Blume	Api-api
2.	Rhizophoraceae	*Rhizophora apiculata* Blume	Bakau Minyak
		Bruguiera parviflora (Roxb.) W.& A. ex Griff.	Lenggadai
		Bruguiera gymnorrhiza (L.) Lamk.	Tumu
		Bruguiera sexangula (Lour.) Poir.	Tumu
3.	Rubiaceae	*Scyphiphora hydrophyllacea* Gaertn. f.	Cinggam
4.	Meliaceae	*Xylocarpus granatum* J. Koenig	Nyirih
5.	Sonneratiaceae	*Sonneratia alba* Smith.	Perepat
6.	Combretaceae	*Lumnitzera littorea* Voigt.	Teruntum Merah
7.	Euphorbiaceae	*Excoecaria agallocha* L.	Madengan/buta-buta
8.	Pteridaceae	*Acrostichum aureum* L.	Paku laut

Table 3. Number of species, number of individuals, and dominant medicinal plant species by observation spot

No.	Station	Number of Individuals	Density (ind/ha)				Classification*	Dominant Species	Coverage (%)
			Tree	Sapling	Seedling	Mean			
1.	I	52	5	21	26	17.33	Sparse	*R. apiculata*	76,73
2.	II	97	13	32	52	32.33	Sparse	*X. granatum*	75,42
3.	III	166	22	13	131	55.33	Sparse	*X. granatum*	74,04
Total		315	40	66	209	104,99	Sparse	Average	75,40

Note: * Decree of the Minister of Environment Number 201 of 2004 concerning Standard Criteria and Guidelines for Determining Mangrove Damage; Sparse (<1,000 ind/ha); Medium (1,000-1,500 ind/ha); dense (>1,500 ind/ha).

Table 4. Measurement results of environmental quality parameters in the mangrove eco-tourism area of Sungai Bersejarah Siak

No.	Station	Temperature (℃)		pH		Water Salinity (‰)	Substrate
		Soil	Water	Soil	Water		
1.	I	26.0	30.0	6.0	6.4	31.0	Muddy soil
2.	II	27.0	31.0	6.0	6.1	31.0	Muddy soil and some sand
3.	III	27.0	31.0	6.0	6.2	30.0	Muddy soil and some sand

A combination of environmental factors creates a suitable environment for the growth and development of mangrove vegetation and the survival of various fauna adapted to mangrove ecosystems. In the Sungai Bersejarah Siak mangrove ecotourism area, various fauna has been identified as living in association with mangroves, including mammals (six species from four families), reptiles (three species from three families), birds (nine species from seven families), and fish (ten species from ten families). The presence of diverse fauna species indicates that mangrove habitats can provide resources and environmental conditions that support fauna life and play an important role in energy flow and nutrient cycling [49, 50]. The diversity of fauna at the study site is also one of the attractions of ecotourism as well as a reflection of good biodiversity conservation efforts to ensure the sustainability of the ecological and economic functions of the mangrove ecosystem. Referring to the results of the assessment of the International Union for Conservation of Nature (IUCN), various fauna species found in the observation site are protected species because of their vulnerable and endangered status, including *M. fascicularis, M. nemestrina, P. cristata, C. nigrorufus,* and *B. bicornis* (Table 5). Some fauna species in the mangrove ecotourism area of the Sungai Bersejarah Siak that were successfully documented by the camera are shown in Figure 5.

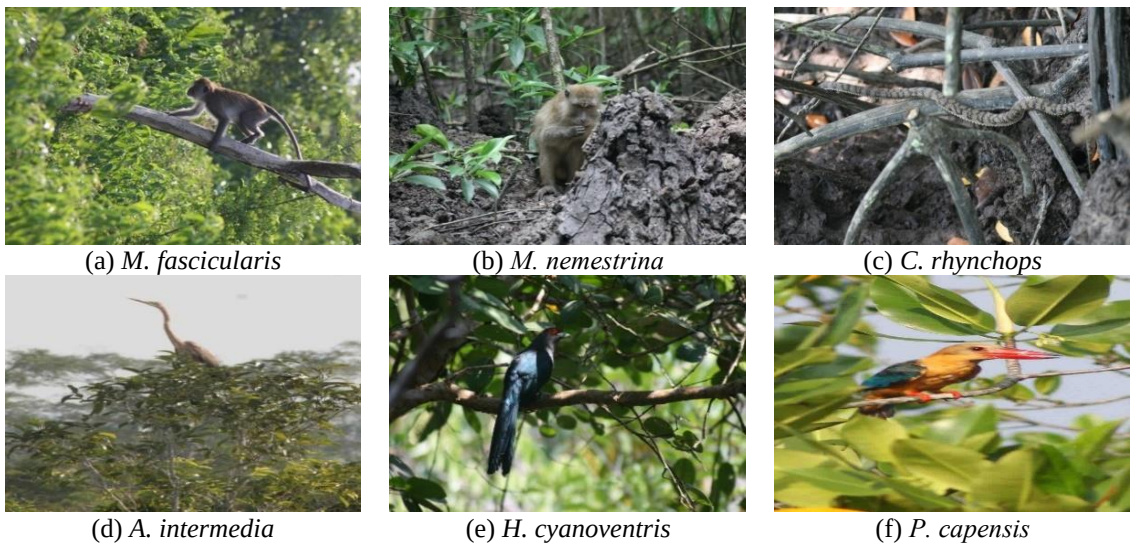
The relatively good physical environment and mangrove vegetation conditions in the Sungai Bersejarah Siak mangrove ecotourism area have provided a suitable habitat for fauna groups that live in association with the mangroves. The discovery of endangered and protected species implies that environmental conditions are relatively stable, reflecting that conservation and environmental management efforts through ecotourism have been carried out effectively. The existence of endangered and protected fauna species is an important indicator of environmental conditions and ecosystem health because fauna with vulnerable and endangered statuses generally have specific habitat requirements and are vulnerable to environmental changes [51]. Protected fauna is one of the main attractions for visitors and is one of the significant internal strengths of mangrove ecotourism management policy strategy sustainably [52].

The ecological conditions maintained in the mangrove ecotourism area of Sungai Bersejarah Siak provide great opportunities to develop the area's potential as a source of ethnobotany. The presence of a healthy mangrove ecosystem not only supports the balance of the local ecosystem but also provides a fertile habitat for traditional medicinal plants that can be utilized by the local community. By utilizing local knowledge and scientific studies, the Sungai Bersejarah Siak mangrove ecotourism area has the potential to become an ethnobotanical research center to identify, study, and develop valuable natural resources for human health and survival, and to promote sustainable environmental conservation. Thus, ecotourism is not only a conservation-based tourist attraction but also has added value in improving the health status of the community, especially the local community around the area.

Table 5. Some types of fauna found in the mangrove ecotourism area of the Sungai Bersejarah Siak

No.	Family	Scientific Name	Local Name	IUCN Status
A.		**Mammals**		
1.	Cercopithecidae	*Macaca fascicularis*	Monyet ekor panjang	EN, 2022
		Macaca nemestrina	Beruk	EN, 2022
		Presbytis cristata	Lutung	VU, 2020
2.	Tupaiidae	*Tupaia glis*	Tupai	DD, 2020
3.	Mustelidae	*Lutra lutra*	Berang-berang	LD, 2021
4.	Equidae	*Sus scrofa*	Babi hutan	LC, 2019
B.		**Reptiles**		
1.	Varanidae	*Varanus salvator*	Biawak	LC, 2021
2.	Colubridae	*Cerberus rhynchops*	Ular bakau	LC, 2010
3.	Crocodylidae	*Crocodylus porosus*	Buaya Muara	LC, 2021
C.		**Birds**		
1.	Alcedinidae	*Halcyon cyanoventris*	Raja udang biru	LC, 2016
		Pelargopsis capensis	Raja udang besar	LC, 2016
2.	Ciconiidae	*Mycteria cinerea*	Bangau	EN, 2023
		Ardea intermedia	Bangau putih	LC, 2020
3.	Cuculidae	*Centropus nigrorufus*	But-but	VU, 2016
4.	Accipitridae	*Haliastur indus*	Elang laut	LC, 2016
5.	Laridae	*Sterna hirundo*	Camar	LC, 2019
6.	Hirundinidae	*Collocalia esculenta*	Layang-layang	LC, 2020
7.	Bucerotidae	*Buceros bicornis*	Enggang	VU, 2020
D.		**Fish**		
1.	Polynemidae	*Eleutheronema* sp.	Kurau	EN, 2015
2.	Scombridae	*Scomberomorus* sp.	Tenggiri	DD, 2023
3.	Chirocentridae	*Chirocentrus* sp.	Parang	LC, 2017
4.	Serranidae	*Epinephelus* sp.	Kerapu	LC, 2018
5.	Centroponidae	*Lates* sp.	Kakap	LC, 2019
6.	Synodontidae	*Harpadon* sp.	Lomek	NT, 2019
7.	Lutjanidae	*Lutjanus* sp.	Jenak	LC, 2016
8.	Clupeidae	*Setipinna* sp.	Biang	LC, 2017
9.	Carangidae	*Selaroides* sp.	Selar	LC, 2016
10.	Plotosidae	*Plotosus* sp.	Sembilang	NA

Note: NA = Not Available; LD = Largely Depleted; DD = Data Deficient; LC = Least Concern; NT = Near Threatened; VU = Vulnerable; EN = Endangered.



(a) *M. fascicularis* (b) *M. nemestrina* (c) *C. rhynchops*

(d) *A. intermedia* (e) *H. cyanoventris* (f) *P. capensis*

Figure 5. Some of the fauna species that have been documented in the mangrove ecotourism area of Sungai Bersejarah Siak

3.2 Ethnobotanical potential of mangrove ecotourism area of Sungai Bersejarah Siak

Medicinal plants are plant species believed to have medicinal properties [53-55]. In general, these properties can be divided into three groups: (i) traditional medicinal plants used as raw materials for traditional medicine, (ii) modern medicinal plants that are medically proven and scientifically proven to contain bioactive compounds with medicinal properties, and (iii) potential medicinal plants that are believed to have medicinal properties, but have not been scientifically proven.

Plants with healing properties can be found in both cultivated and uncultivated areas, including mangrove vegetation. Certain parts of the mangrove plant are capable of producing various phytochemicals. The content of these phytochemicals varies greatly depending on the type of mangrove vegetation and provides a wide range of pharmacological effects [38, 39]. Its pharmacological effects include antibacterial [56], antioxidant [57], antiviral [42, 43],

anticancer [58-60], antidiabetic [61], antihypertensive [62], and neuroprotective [63] effects. This is thought to be because of the phytochemical biological components present in these natural ingredients, including carotenoids, tannins, polyphenols, steroids, flavonoid alkaloids, phenolic acids, saponins, phenylpropanoids, and glucoside [6, 16, 45, 46].

The results of this study indicate that traditional medicine still plays an important role in meeting the basic healthcare needs of residents in the mangrove ecotourism area of Sungai Bersejarah Siak. The survey showed variations in respondents' knowledge levels between 33.33% and 90.48% regarding the use and benefits of several types of mangrove vegetation in traditional medicine, with a relatively high average knowledge level of 63.27%. The respondents reported that seven plant species from five families were used in traditional medicine. Rhizophoraceae (3 species) was the most represented family, followed by Verbenaceae, Meliaceae, Sonneratiaceae, and Pteridaceae, each with 1 species (Table 6). This shows that 63.64% of mangrove species in the Sungai Bersejarah Siak mangrove ecotourism area are utilized by local communities as a source of traditional medicine and have the potential for further development.

Table 6. Phytochemical composition and traditional medicinal uses of various mangrove species in mangrove ecotourism area Sungai Bersejarah Siak

No.	Family	Botanical Name	Local Name	Habitus	Type	Phytochemical Property	Medicinal Use	Informants' Citation		References
								Frequency	Percentage	
1.	Verbenaceae	*A. alba*	Api-api	Tree	***	Alkaloids, tannins, flavonoids, triterpenoids, steroids, saponins, phenolic, quinones, carotenoids	Antifertililty (Re, Sa), skin diseases, ulcers, rheumatism, ulcers, boils, skin diseases (St, B, Re), smallpox (B, S), diarrhea, stomach acid (L), antitumor, anticancer (WP)	23	54.76	[6, 64-70]
2.	Rhizophoraceae	*R. apiculata*	Bakau minyak	Tree	***	Alkaloids, tannins, saponins, phenolics, flavonoids, triterpenoids, steroids, glycosides, phenolic	Antiemetic, antiseptic, diarrhea, hemostatic (B), hepatitis (B, Fl, Fr, L), stop bleeding (L, B), typhus (B), elephantiasis, hematoma, hepatitis, ulcer, febrifuge (WP)	36	85.71	[6, 14, 64, 65, 68, 71, 72]
		B. pa	L en	S	** *	Phenolic, steroids, polyphenols	Antitumor, anticancer, antidiabetic (B), antioxidant (L), herpes (Fr)	14	33.33	[6, 16, 21, 68, 73, 74]
		B. gymnorrhiza	Tumu merah	Tree	***	Flavonoids, saponins, tannins, gums, steroids	Eye diseases (Fr), treating ear infections (Fl), diarrhea (L), constipation, burns, antihyperglycemic, analgesic, antioxidant, anti-inflammatory, anti-diabetic, pain, liver disorders, fever, herpes, zoster, malaria, abortifacient (R, L)	38	90.48	[6, 21, 64, 65, 68, 75]
3.	Meliaceae	*X. granatum*	Nyirih	Tree	**	Flavonoids, alkaloids, steroids, limonoids, tannins, triterpenoids, saponins	Cholera, fever, malaria, antidiabetic (B), diarrhea (B, L, Fr), microbes (L), hyperglycemia, dyslipidemia (Fr)	17	40.48	[14, 64, 66, 68, 74, 76]
4.	Lythraceae	*S. alba*	Pedada	Tree	***	Flavonoids, Tannins, Phenolic, Saponins, Phenylpropanoids, Steroids	Cough, swelling, sprain (Fr), Anti-parasite (L)	31	73.81	[14, 64, 65, 68, 77]
5.	Pteridaceae	*A. aureum*	Paku laut	Tree	**	Glucoside, saponins, steroids	Stop bleeding, relieve pain, ulcers, wounds (Rh), rheumatism (L)	27	64.29	[6, 68]

Note: ⁎⁎⁎ = Mangroves; ⁎⁎ = Mangrove minors; ⁎ = Mangrove associates; (B) = Bark; (F) = Fruit; (Fl) = Flower; (Rh) = Rhizome; (L) = Leaves; (Re) = Resin; (R) = Root; (Sa) = Sap; (S) = Seed; (St) = Stem; (T) = Twig; (WP) = Whole plant; (NI) = Not indicated.

All plant species used as medicines by residents around the study site were supported by scientific references. Based on scientific references, several phytochemical contents have been identified in these plants, including alkaloids, tannins,

flavonoids, triterpenoids, steroids, saponins, phenols, quinones, carotenoids, glycosides, polyphenols, gums, limonoids, phenylpropanoids, and glucoside, which play a role as health support [6, 16, 45, 46]. Plants with therapeutic properties can be classified as medicinal plants [54].

According to the locals and supported by the literature, the plant parts used for medicinal purposes are bark, fruit, flowers, rhizomes, leaves, resin, roots, sap, seeds, stems, twigs, and all parts of the plant [14, 16, 17, 65]. *B. gymnorhiza* (90.48%) and *R. apiculata* (85.71%) are the species most widely used by local communities around the Sungai Bersejarah Siak mangrove ecotourism area for traditional medicine compared to other species. Species such as *B. gymnorhiza* (17%), *R. mucronata* (14%), *A. ilicifolius* (10%), and *H. fomes* (9%) are widely practiced and have a variety of potential medicinal values compared with other species [16].

Local people usually use several types of mangroves for various purposes (Table 6), such as stopping bleeding, relieving pain, preventing pregnancy, as antioxidants, healing wounds, neutralizing toxins, removing tongue fungus, treating skin itching, disguising smallpox scars, smoothing the skin, relieving muscle pain, restoring stamina, and increasing appetite. In addition, the plant is used to treat various diseases, including toothache, liver disease, diarrhea, herpes, ear infections, lumbago, rheumatism, malaria, and appendicitis. The use of the plant as an antitumor, anticancer, and antidiabetic agent is not widely known by local communities because of the lack of information regarding the potential of mangroves for these benefits. Therefore, education and dissemination of information related to the potential and efficacy of mangroves as medicinal plants must continue to be socialized to the community, especially the younger generation.

The existence of mangroves as medicinal plants has a significant relevance to human health, especially in coastal communities. Mangroves not only provide diverse natural resources but also contain active compounds with medicinal potential. This potential has not yet been optimized. This can be seen from the use of mangroves as medicinal plants in Indonesia, which is still low, at only 3.4%, compared to other Asian countries such as India (45.8%), Bangladesh (5.1%), Malaysia (5.1%), and China (5.1%) [16]. Understanding the existence of mangroves as medicinal plants also opens opportunities for further research into the development of modern plant-based medicines, which can contribute to the pharmaceutical industry while maintaining the sustainability of mangrove ecosystems and supporting the sustainable lives of coastal communities. Therefore, preservation and further understanding of the role of mangroves as medicinal plants are essential to utilize this natural heritage wisely and sustainably.

In the sustainable management policy strategy in several mangrove ecotourism areas in the Siak Regency by Erlinda et al. [52], it is known that the mangrove education variable is one of the strength variables in the internal factor matrix, in addition to the diversity of flora and fauna. This condition allows further development of ethnobotanical education in ecotourism areas in Siak District as a strength that must be optimally developed by integrating local knowledge and scientific literacy to promote public health and environmental conservation.

The development of ethnobotanical potential in the Sungai Bersejarah Siak mangrove ecotourism area is of significant added value, which has so far focused only on natural tourist attractions. The study of ethnobotanical potential that utilizes local knowledge and scientific literature provides valuable information to improve health status, which can be included as one of the variables of sustainability in mangrove ecotourism area management. Thus, the Sungai Bersejarah Siak mangrove ecotourism area is not only an attractive tourist destination and contributes to environmental conservation but also a source of knowledge and benefits for local communities and the scientific world related to medicinal plants.

4. CONCLUSIONS

The Sungai Bersejarah Siak mangrove ecotourism area possesses significant ecological and ethnobotanical value, characterized by its diverse flora and fauna, as well as a variety of medicinal plants. The area supports various ecosystems, including mangrove forests and riverine habitats, which form a dynamic ecological network involving at least 28 species of fauna, including mammals, reptiles, birds, and fish, coexisting with 11 mangrove species from eight different families. The presence of endangered and protected species indicates stable environmental conditions and effective conservation measures, thereby highlighting the importance of this area for biodiversity conservation. Furthermore, the ethnobotanical potential of this mangrove ecotourism area is evident through the use of seven species from five mangrove families by local communities for traditional medicine, demonstrating the extensive knowledge of their applications. This potential is further supported by the diverse phytochemical contents of these plants, which have therapeutic effects utilized by the local community to address various health problems. These characteristics present valuable opportunities for developing sustainable ethnobotanical education and expanding the research on plant-based medicines. Therefore, the Sungai Bersejarah Siak mangrove ecotourism area not only serves as a conservation-focused tourist destination but also significantly contributes to public health and the economic development of the local community. Future management strategies should include comprehensive education programs and research initiatives to further explore the ethnobotanical and medicinal potential of mangrove species, thereby promoting ecological sustainability and public health.

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