

Ethnobotanical study and conservation strategy of medicinal plants in the ecotourism area of Kedah Rainforest Lodges in Aceh, Indonesia

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Abstract. Ridwan, Zahrah M, Rahmawaty. 2022. *Ethnobotanical study and conservation strategy of medicinal plants in the ecotourism area of Kedah Rainforest Lodges in Aceh, Indonesia. Biodiversitas* 23: 6227-6237. Medicinal plants have long been used by indigenous communities, including Gayo people in Aceh, Indonesia. The conservation and sustainable utilization of medicinal plants can be integrated with ecotourism activities. Kedah Rainforest Lodges is an ecotourism area in the Protected Forest area of Forest Management Unit (FMU) Region V Aceh, Indonesia, which is an important source of medicinal plants, clean water and nature tourism. However, biodiversity in the area is threatened by excessive human activity, including the long-standing tradition of Gayo people using medicinal plants. Therefore, this study aimed to investigate medicinal plants used by the local community living around Kedah Rainforest Lodges using an ethnobotanical approach and to identify a strategy for the conservation of medicinal plants using strengths, weaknesses, opportunities and threats (SWOT) analysis. A combination of field observations, interviews, documentation and focus group discussions were employed for data collection. The result of the ethnobotanical study identified 44 species belonging to 31 families of medicinal plants used by Gayo people in the studied area. Asteraceae is the family with the largest number of medicinal plant species, while herbs are the most common habitus of the medicinal plants and leaves are the most used plant part. Based on SWOT analysis, there are several strategies to conserve medicinal plants in Kedah Rainforest Lodges, including (i) the rehabilitation of degraded areas through the enrichment of medicinal plants to create living pharmacies; (ii) the development of facilities to support medicinal plants ecotourism; and (iii) partnerships with related stakeholders to obtain funding and enhance the capacity of the area manager and staff.

Keywords: Ecotourism, Gayo people, inventory, medicinal plants, SWOT analysis

INTRODUCTION

Indonesia hosts a diversity of more than 40,000 plant species, 6000 of which are used in traditional medicine (Elfahmi et al. 2014). Herbal medicine plays an important role in maintaining the primary health system in Indonesia and many other countries, especially in the remote areas of developing countries where herbal medicine is the only medicine available (Vitalini et al. 2013; Hoang et al. 2019). In fact, more than 80% of the world's population depends on herbal medicine (Alsarhan et al. 2012), and its use continues to grow rapidly (Ekor 2014) as increasingly intense interactions between humans and plants increase human knowledge and expertise in utilizing medicinal plants (Yeung et al. 2020).

Several studies on medicinal plants have been conducted (Rahmawaty et al. 2019a; Silalahi et al. 2015; Musinguzi 2017; Pandiangan et al. 2019), especially in Indonesia (Purba et al. 2016; Rahmawaty et al. 2019b), where many indigenous peoples have been long using medicinal plants, including the Gayo people in Aceh Province and the Karo people in North Sumatra Province, both on the island of Sumatra (Purba et al. 2016). The Gayo people, who live in the highlands of Aceh Province,

closely observe customs established by their ancestors and possess extensive local wisdom in using natural resources, including plants to cure diseases, passed down from generation to generation. In a similar case, the Dayak people on the island of Borneo also use medicinal plants as the first-line alternative to cure diseases (Supiandi et al. 2019; Yuan et al. 2016). For example, communities in the villages of Penosan Sepakat and Penosan, Aceh Province, use 72 plant species belonging to 42 families for medicinal purposes with habitus ranging from trees (33.3%), shrubs (30.6%), herbs (29.2%) and lianas (6.9%), and the plant parts mostly used are leaves (39.3%), fruit (12.4%), whole parts (13.8%), tubers (11.0%), roots and skin (7.6%), flowers and stems (2.8%), seeds (2.1%) and sheaths (0.7%) (Kasrin et al. 2019).

Forest provides various environmental goods and services which are essential for the community living around the forest. Around the world, including in Indonesia, forest-based communities areas depend on nature to meet their needs, with an estimated more than 1.6 billion people using forest resources for livestock grazing, fuel, medicine and their general livelihoods (Banerjee and Madhurima 2013). This includes communities living around Kedah Rainforest Lodges. This forest is an ecotourism area in Gayo Lues District in Aceh Province,

Indonesia, managed under the Forest Management Unit (FMU) Region V in Protected Forest Area V, Aceh Utilization Block. Covering an area of approximately 767 Ha, the ecotourism area is managed based on the Cooperation Agreement (No. 050/532-5/VII.6 and No. 02/RFLK-5/2021) between the FMU Region V in Aceh and the Forest Farmers Group and is a vital source of medicine, clean water, nature tourism and flora and fauna habitats.

According to the land cover data presented in the Long-Term Forest Management Plan of FMU Region V Aceh for 2019-2028, Kedah Rainforest Lodges includes an area of approximately 137 Ha adjacent to plantations and near roads that is prone to encroachment and land conversion (DLHK Aceh 2019). In such landscape configurations where the natural ecosystem is close to anthropogenic activities, land use changes present a major threat to biodiversity (Marques et al. 2019). Land use changes have the potential to degrade or destroy natural ecosystems and increase the fragmentation of natural or semi-natural habitats (Ellis et al. 2013). The extent and intensity of ecosystem destruction and degradation are expected to increase further due to the rapid growth of human populations, economic growth and changes in lifestyle and diet (Erb et al. 2016). In the context of medicinal plant resources, forest degradation and habitat destruction are the major causes of the loss of diversity and abundance of medicinal plants (Chen et al. 2016). Although such destruction is largely due to human activity (Sloan and Sayer 2015), it is exacerbated by a lack of local knowledge about the ways of preserving medicinal plants in the forest, which could be disastrous not only for the environment and society but also the state (Hidayat et al. 2021). As a consequence, several species of medicinal plants have begun to decrease in number and even lost part or all of their habitats (El-Shabasy 2017), which adversely impacts the livelihoods of people who depend on forests (Boafo 2013).

In response, efforts in conservation are needed to ensure the diversity of medicinal plant species and the sustainability of the area, both of which support the economy and society in the surrounding community. To that end, in our study, we sought to identify species of medicinal plants in the ecotourism area of Kedah Rainforest Lodges and to examine a strategy for the conservation of medicinal plants using strengths, weaknesses, opportunities and threats (SWOT) analysis. We expect the results of this study can become a reference for relevant stakeholders for sustainable management of the area.

MATERIALS AND METHODS

Study period and area

The study was conducted from March to December 2021 in the ecotourism area of Kedah Rainforest Lodges (Protected Forest area of Forest Management Unit (FMU)

Region V Aceh) in Penosan Sepakat Village, Blangjerango Sub-district, Gayo Lues District, Aceh Province, Indonesia. Geographically, the area is located in the Leuser ecosystem at an altitude of 1200-2800 m above sea level. Land coverage is dominated by primary forest, followed by secondary forest, shrubs and dry land agriculture of tobacco, coffee and secondary crops in mostly podsolic and cambisol soil types. A map of the study area is presented in Figure 1.

Data collection procedure

Inventory of medicinal plants

The plants observed and identified in each plot are all plant species used by the Gayo people found in the ecotourism area. There were 33 observation plots established after surveying the availability of medicinal plants in the land unit. Observations were made on all species of habitus consisting of trees, lianas, bushes, herbs and shrubs. Following Soerianegara and Indrawan (1998), we classified based on growth stage, namely: (i) tree level (i.e. diameter >20 cm), (ii) pole level (i.e. 10-19 cm diameter), (iii) sapling level (i.e. min. height of 1.5 m and diameter of 5-10 cm) and (iv) seedling level (i.e. rejuvenation stake >1.5 m tall and diameter <5 cm). Following Kusmana (1997), the sample plot size to be 20 m × 20 m for trees, 10 m × 10 m for poles, 5 m × 5 m for saplings and 2 m × 2 m for all seedlings, lianas and other understorey plants (Figure 2).

Medicinal plant species were identified in the field with the aid of key informants who participated in semi-structured interviews using the local language (Megersa and Woldetsadik 2022). Key informants, selected via purposive sampling with certain considerations (Sugiyono 2012), were the members of *Guru Kampung*, namely the Gayo tribal community, with expertise in the traditional processing and use of medicinal plants. The interviews aimed to collect information about medicinal plant species found in the observed plots, including local names, benefits, parts used and ways of use.

Strategy for the conservation of medicinal plants based on SWOT analysis

In the SWOT analysis, a focus group discussion was conducted with participants representing various stakeholders. The informants from each agency, namely one person from the Gayo Lues District Tourism Office, the Village Government of Penosan Sepakat, the Village Government of Penosan, Gunung Leuser National Park Forest Police, Forest Protection FMU Region V Aceh, academics, non-governmental organizations, members of *Guru Kampung* and ecotourism managers. In the discussion, the participants identified internal factors (i.e. strengths and weaknesses) and external factors (i.e. opportunities and threats) concerning the ecotourism area of Kedah Rainforest Lodges as well as ranked each internal and external factor.

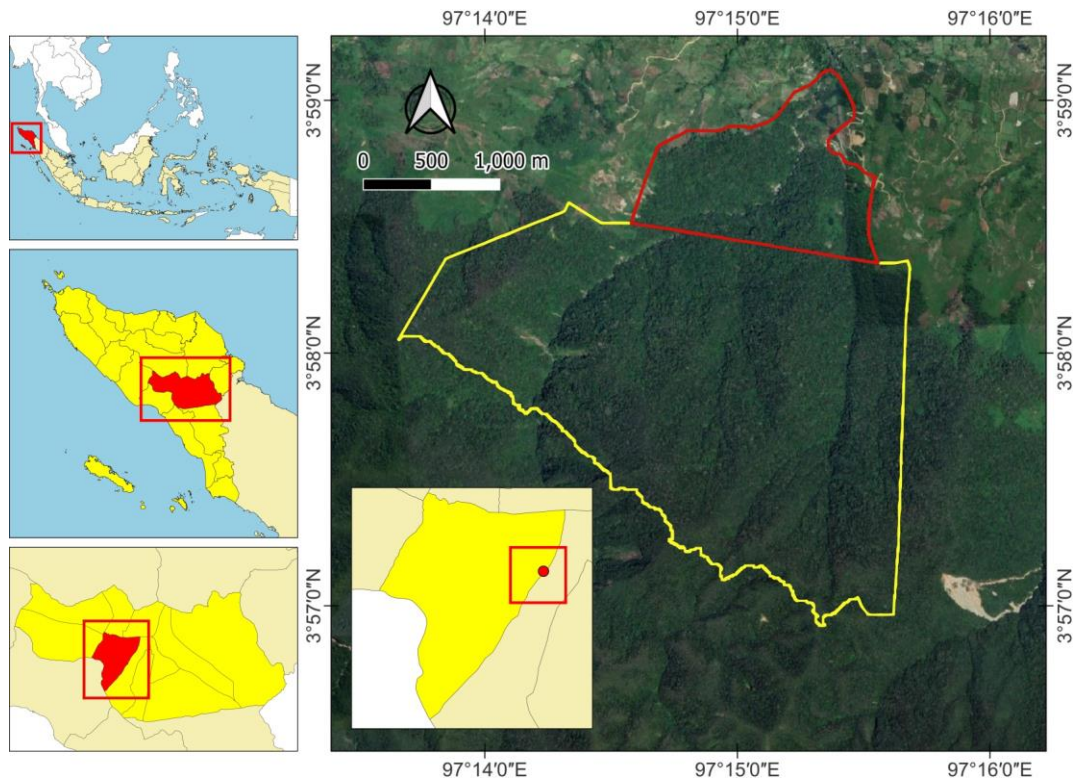


Figure 1. Map of the study area in the Kedah Rainforest Lodges ecotourism area, Blangjerango Sub-district, Gayo Lues District, Aceh Province, Indonesia

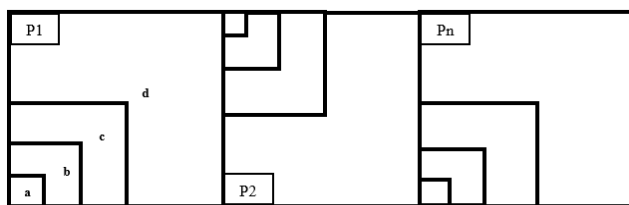


Figure 2. Design of sample plots for the inventory of medicinal plant species. Note: (a) Subplot for seedlings, lianas and other understorey plants (2 m × 2 m), (b) subplot for sapling (and shrub) level (5 m × 5 m), (c) subplot for pole level (10 m × 10 m) and (d) subplot for tree level (20 m × 20 m)

Data analysis

Inventory of medicinal plant species

The data resulting from the inventory of medicinal plants were cross-checked with the book *Medicinal Plants Economic Prospects for Non-Timber Forest Products of Nangroe Aceh Darussalam and the Banua Botanical Garden Collection: Potentially Medicinal Plants*. Data were analyzed descriptively in descriptions, tables, illustrations and photographs of medicinal plant species found in the ecotourism area of Kedah Rainforest Lodges.

Determination of conservation strategy using SWOT analysis

After the focus group discussion, data analysis was performed by determining each score for the internal and external factors and making SWOT diagrams and matrices in order to produce a set of strategies for the conservation

of medicinal plants in the Kedah Rainforest Lodges ecotourism area. The weighting of each strategic factor starts from a scale of 0.0 (not important) to 1.0 (very important) with a total score of 1.00. The score was obtained by multiplying the weight and rating for each factor (Utsalina et al. 2020).

RESULTS AND DISCUSSION

Composition of medicinal plants in the ecotourism area of Kedah Rainforest Lodges

An inventory of medicinal plants was carried out in an ecotourism area consisting of several types of land cover, namely primary forest (68%), secondary forest (18%), dry land agriculture (12%) and shrubs (2%). There were 44 species belonging to 31 families of medicinal plants identified in the ecotourism area of Kedah Rainforest Lodges, as shown in Figure 3.

Eight categories of the parts of the medicinal plants were reported to be used by the community, namely leaves, stems, bark, flowers, roots, fruit, sap and the entire plant, as shown in Figure 5.

List of medicinal plant species in the ecotourism area of Kedah Rainforest Lodges

The medicinal plant species identified in the Kedah Rainforest Lodges ecotourism area and used by the Gayo people as medicine are listed in Table 1, and some are illustrated in Figures 6A-C.

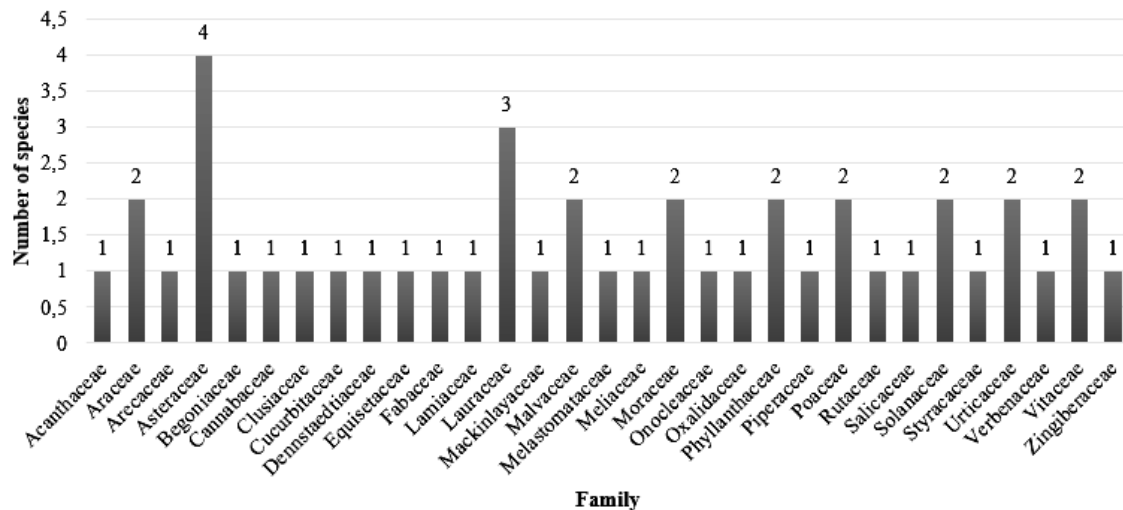


Figure 3. Number of medical plant species identified in each family

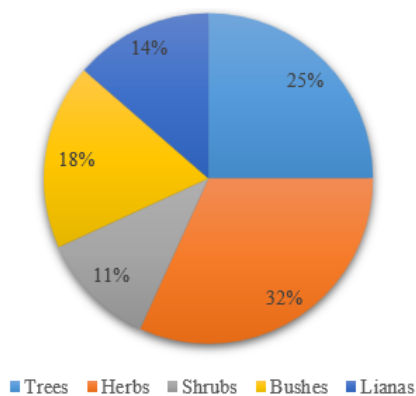


Figure 4. Percentage of medicinal plant species identified based on habitus

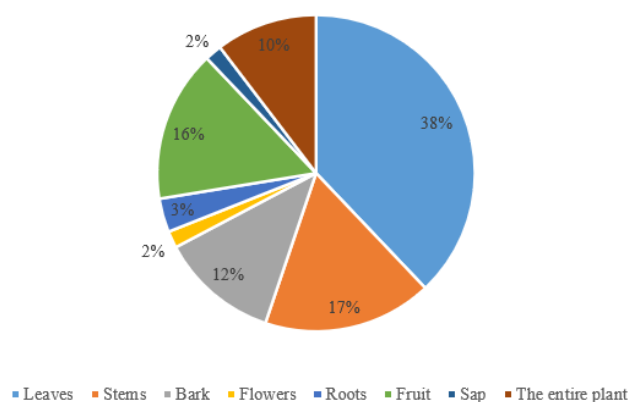


Figure 5. Percentage of the parts of the medicinal plants used



Figure 6. Some medicinal plants used by Gayo people in Kedah Rainforest Lodges, Aceh, Indonesia: A. *Ficus punctata* Thunb; B. *Teucrium canadense* L; C. *Styrax benzoin* Dryand

Strategy for the conservation of medicinal plants

The internal and external factors affecting the conservation of medicinal plant species in Kedah Rainforest Lodges based on the results of the focus group discussion are shown in Tables 2 and 3.

Based on Tables 2 and 3, the total score for internal factors (2.65) and external factors (2.40) in ecotourism areas is at a moderate level or average value. This shows how the

reaction of the development of ecotourism areas to the opportunities and threats that exist. The score is to find out how much the factors influence or impact each strategy factor. The calculated internal factor score of strengths minus weaknesses was 1.90 - 0.75, and the value of the x-axis was 1.15. The score for opportunities minus threats was 1.65 - 0.75, and the value of the y-axis was 0.90. The SWOT diagram is shown in Figure 7.

Table 1. Species information and conservation status of medicinal plants in the ecotourism area of Kedah Rainforest Lodges, Aceh, Indonesia

Species name		Habitus	Family	Medicinal use	Part used	Mode of use	Conserv. status (IUCN, 2022)*
Local name	Scientific name						
Bebesi	<i>Ruellia simplex</i> C. Wright	Herbs	Acanthaceae	Overheating	Whole parts	Mixed with water and other plants and then sprinkled on the body	-
Kayu Panu	<i>Amorphophallus muelleri</i> Blume	Herbs	Araceae	Tinea versicolor	Stems	Hit to the body	-
Keladi	<i>Homalomena rubescens</i>	Herbs	Araceae	Bee-sting	Stems	Crush and apply to the affected area	-
We Pukuh	<i>Calamus rotang</i> L	Lianas	Arecaceae	Toothache	Stems	Dried and burned until sap appears, then applied to the teeth using cotton	-
Penyamung Nyawa	<i>Gynura procumbens</i> (Blume) Miq.	Shrubs	Asteraceae	Diabetes	Leaves	Boiled then the water is drunk	-
Sesemuh	<i>Acmella uliginosa</i> (Sw.) Cass.	Herbs	Asteraceae	Toothache	Flowers	Milled and applied on the affected tooth	-
Gedomak	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Herbs	Asteraceae	Itch	Leaves	Crushed and then smoked	-
Dilembu	<i>Ageratum conyzoides</i> L	Herbs	Asteraceae	Itch, gout	Leaves	Itching: mashed and then rubbed Gout: boiled and drunk	-
Begonia	<i>Begonia pseudoscottii</i>	Herbs	Begoniaceae	Stomachache, high blood pressure, wounds	Stems	Stomachache: stems are eaten High blood pressure: stems are boiled then the water is drunk Wounds: crushed then applied to the wound	-
Kerto	<i>Trema orientalis</i> (L.) Blume.	Trees	Cannabaceae	Diabetes	Fruits	Fruits are eaten	-
Kanis	<i>Garcinia atroviridis</i> Griffith et Anders.	Trees	Clusiaceae	Delirium	Leaves, bark	Crushed and then rubbed all over the body	-
Lelon Kera	<i>Trichosanthes bracteata</i> (Lam.) Voigt.	Lianas	Cucurbitaceae	Trance	Leaves	Crushed and then rubbed all over the body	-
Kekuyang	<i>Pteridium aquilinum</i> (L.) Kuhn	Herbs	Dennstaedtiaceae	Boils	Stems	Smoothed then applied to the edge of the boil	-
Sesenep	<i>Equisetum ramosissimum</i> Desf.	Herbs	Equisetaceae	Sprains	Whole section	Smoothed then rubbed	LC
Kerukuen	<i>Desmodium intortum</i> (Mill.) Urb.	Bushes	Fabaceae	Sprains	Leaves	Smoothed then rubbed	LC
Rereges Koro	<i>Teucrium canadense</i> L	Shrubs	Lamiaceae	Wounds, animal bites	Leaves	Squeezed or crushed in a paste and applied to the affected area	-
Kulit Manis	<i>Cinnamomum verum</i> , sin. C. Zeylanicum	Trees	Lauraceae	Cold	Bark	Kneaded then rubbed	-
Pokad	<i>Persea americana</i> Mill	Trees	Lauraceae	High blood pressure	Leaves, fruit	Leaves are squeezed and drunk	LC
Kulit Lawang	<i>Cinnamomum cuspidatum</i> Miq.	Trees	Lauraceae	Cold	Bark	Crushed and then swept into the body	LC
Pegege	<i>Centella asiatica</i> (L) Urban	Herbs	Mackinlayaceae	Overheating	Leaves	Crushed and pasted	LC
Pelulut	<i>Urena lobata</i> L	Bushes	Malvaceae	Overheating	Whole section	Mixed with water and other plants and then sprinkled on the body	LC
Jejerun	<i>Sida rhombifolia</i> L	Bushes	Malvaceae	Overheating	Whole section	Mixed with water and other plants and then sprinkled on the body	-
Bebeke	<i>Melastoma malabathricum</i> L	Shrubs	Melastomataceae	Fatigue	Roots	Boiled then the liquid is drunk	-
Balik Angin	<i>Aglaia arganthea</i> Blume	Trees	Meliaceae	Fever	Leaves	Squeezed, rubbed and boiled then applied the water to the body	-

Nangka	<i>Artocarpus heterophyllus</i> Lamk.	Trees	Moraceae	Stomachache, eye pain	Fruit	Stomachache: eaten Eye pain: crushed and dropped into the eye	-
Konyel	<i>Ficus punctata</i> Thunb.	Lianas	Moraceae	Stomachache	Bark	Eaten	-
Dedurang	<i>Matteuccia struthiopteris</i> (L.) Tod.	Herbs	Onocleaceae	Itch	Whole section	Mixed with water and other plants and then sprinkled on the body	LC
Lela	<i>Oxalis corniculata</i> L	Herbs	Oxalidaceae	Overheating	Whole section	Crushed and then rubbed into the body	-
Tingkem	<i>Bischofia javanica</i> Blume	Trees	Phyllanthaceae	Wounds	Bark	Crushed and then applied to the wound	LC
Aging	<i>Antidesma riparium</i> Airy Shaw	Trees	Phyllanthaceae	Boils	Leaves	Leaves crushed into a paste and applied to the boil	-
Pianang	<i>Piper caducibracteum</i> C.DC	Lianas	Piperaceae	Bee-sting, wasp- sting	Leaves	Crushed and then rubbed into the affected area	-
Teteguh	<i>Eleusine indica</i> (L.) Gaertn	Herbs	Poaceae	Overheating	Stems	Mixed with other plants and sprinkled on the body	LC
Jih	<i>Imperata cylindrica</i> (L.) Raeusch	Herbs	Poaceae	Measles	Leaves	Boiled, after which the water is drunk	-
Mungkur Uten	<i>Citrus macroptera</i> Montrouz.	Shrubs	Rutaceae	Trance	Fruit	Cut into pieces and then put into a basin of water, then squeezed and the water is swept all over the body	-
Tenggulun	<i>Flacourtia rukam</i> Zoll. and Moritz.	Trees	Salicaceae	Acid reflux, diarrhoea	Fruit	Eaten	-
Ongke	<i>Solanum torvum</i> Sw	Shrubs	Solanaceae	Bee-sting, wasp- sting	Fruit	Crushed and rubbed the affected part of the sting	-
Nyelki	<i>Solanum mauritianum</i> Scop.	Shrubs	Solanaceae	High blood pressure	Leaves, roots	Boiled, after which the water is drunk	-
Kemiyen	<i>Styrax benzoin</i> Dryand	Trees	Styracaceae	Used in community medicine	Sap	Burned	-
Latong	<i>Laportea stimulans</i> (Lf) Gaud	Shrubs	Urticaceae	Bacterial infection	Leaves	Boiled and the steam is wafted towards the body	-
Pepus	<i>Poikilospermum suaveolens</i> (Blume) Merr.	Lianas	Urticaceae	Eye redness, back pain	Stems (water)	Drunk	-
Rum-Rum	<i>Stachytarpheta jamaicensis</i> Vahl	Bushes	Verbenaceae	Boils	Leaves	Smoothed and attached to the boil	LC
Pangang Babi	<i>Leea indica</i> (BURM.f) Merr.	Bushes	Vitaceae	Boils	Leaves	Smoothed and attached to the boil	LC
Lembayung	<i>Tetrastigma leucostaphylum</i> (Dennst.) Alston ex Mabb.	Lianas	Vitaceae	Overheating	Leaves	Crushed and then rubbed into the body	-
Cekala	<i>Etlingera elatior</i> (Jack) R.M. Smith	Herbs	Zingiberaceae	Fever, delirium	Leaves	Boiled water is swept into the body	DD

Note. LC: Least Concern, DD: Data Deficient

Table 2. Matrix of internal factor analysis for the strategy for the conservation of medicinal plants in Kedah Rainforest Lodges, Aceh, Indonesia

Internal factors	Weight	Rating	Score
Strength (S)			
Kedah Rainforest Lodges has a moderate diversity of medicinal plant species.	0.1	3	0.30
Natural conditions remain dominated by primary forest and have great potential for the conservation of medicinal plant species.	0.05	4	0.20
There is a strong desire of stakeholders to maintain the maximum and sustainable preservation of medicinal plants.	0.2	4	0.80
Kedah Rainforest Lodges's ecotourism management has received recognition and/or permissions from regional stakeholders.	0.15	4	0.60
Score	0.50		1.90
Weakness (W)			
Medicinal plants do not currently receive special attention.	0.2	1	0.20
The medicinal plant species has not been fully identified	0.1	2	0.20
Management costs cause suboptimal ecotourism protections.	0.15	2	0.30
Signage regarding the area's boundaries with community plantations are not available.	0.05	1	0.05
Score	0.50		0.75
Total	1.0		2.65

Table 3. Matrix of external factor analysis for the strategy for the conservation of medicinal plants in Kedah Rainforest Lodges, Aceh, Indonesia

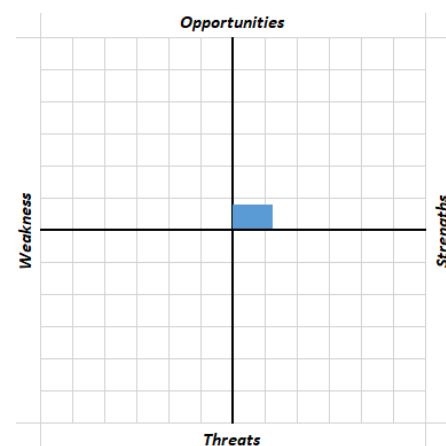
External factors	Weight	Rating	Score
Opportunity (O)			
Ecotourism areas can become the centre for the study and development of knowledge of the surrounding community by creating an educational forest.	0.2	3	0.6
Ecotourism areas can be developed into living pharmacies to meet the needs of the community.	0.1	4	0.4
Donors and related parties are interested in supporting the conservation of the area.	0.15	3	0.45
Ecotourism areas can be developed based on the conservation of medicinal plant biodiversity.	0.05	4	0.2
Score	0.50		1.65
Threat (T)			
The use of medicinal plants is widespread, excessive and unsustainable.	0.15	1	0.15
Land conversion causes a high level of loss of medicinal plant species in their natural habitats.	0.2	2	0.4
There is no protection for medicinal plant species in the Kedah Rainforest Lodges ecotourism area.	0.05	2	0.1
The area is prone to encroachment from the expansion of plantations.	0.1	1	0.1
Score	0.5		0.75
Total	1.0		2.40

Table 4. Formulation of the SWOT matrix for the strategy for the conservation of medicinal plants in Kedah Rainforest Lodges, Aceh, Indonesia

	Strength (S)	Weakness (W)
Opportunity (O)	SO strategy = $1.90 + 1.65 = 3.55$	Strategy WO = $0.75 + 1.65 = 2.40$
Threats (T)	Strategy ST = $1.90 + 0.75 = 2.65$	WT strategy = $0.75 + 0.75 = 1.50$

Figure 7 shows that the position of the strategy for the conservation of medicinal plants in the Kedah Rainforest Lodges ecotourism area is in Quadrant 1 (i.e. SO). In that advantageous position, there is the power to take advantage of all opportunities to optimally implement the strategy for the conservation of medicinal plants. The formulation of the SWOT matrix strategy for the conservation strategy is presented in Table 4.

As shown in Table 4, the results of the internal factor analysis ($S = 1.90$ and $W = 0.75$) and external factor analysis ($O = 1.65$ and $T = 0.75$) matrices show that Kedah Rainforest Lodges ecotourism area can use opportunities to best minimize weaknesses and use strengths as capital for countering threats.

**Figure 7.** The SWOT diagram showing the strategy for the conservation of medicinal plants in the Kedah Rainforest Lodges, Aceh, Indonesia

Discussion

The Gayo community has had a close relationship with nature long before the development of modern life, and to meet their daily needs, the community utilizes timber forest products and various non-timber forest products, including medicinal plants. In Gayo society, medicinal plants are used to treat not only physical health problems but also diseases that the community believes to be caused by metaphysical disturbances, and for any treatment using traditional medicinal plants, people usually visit the village healer-teacher or locally known as *Guru Kampung* (Kasrin et al. 2019). Medicinal and other plants also have religious value and are used in ceremonies such as weddings, circumcisions, *tawar kampung*. Likewise, the Acehnese people, also living in northern Sumatra, use plants in various rituals to commemorate events such as marriages, births and deaths (Sutrisno et al. 2020).

Our inventory of medicinal plants in the ecotourism area of Kedah Rainforest Lodges revealed 44 medicinal plant species in 31 families. Earlier, Wijana and Rahmawati (2020) documented 28 plant species with medicinal properties in the Ubud Monkey Forest in Indonesia, while 38 species were identified in the forest of Mount Furi in Ethiopia by Abebe et al. (2022). According to our interviews with key informants, medicinal plant species in the Kedah Rainforest Lodges ecotourism area have been decreasing due to forest encroachment, which has caused several such species, including *Ficus punctata* Thunb and *Garcinia atroviridis* Griffith et Anders to disappear from their natural habitats. Meanwhile, *Bischofia javanica* Blume and several other medicinal plant species have been adversely affected by degradation, deforestation and land use changes caused by local communities. Anthropogenic disturbances in the form of logging, fires, hunting, trapping and edge effects are the driving forces behind the loss and destruction of the remaining forests and, resulting in a decrease in biodiversity (Barlow et al. 2016).

The medicinal plant species that we identified are mostly from the Asteraceae family, which accounted for four of the 44 species, or 9% of all medicinal plant species documented. Several studies in Ethiopia (Tekla et al. 2020; Assefa et al. 2021; Megersa and Woldetsadik 2022), India (Khajuria et al. 2021) and Morocco (Chaachouay et al. 2022) showed similar findings. The second-largest family in our inventory is Lauraceae with three species (7%), whereas the least represented families are Acanthaceae, Araceae, Begoniaceae, Cannabaceae, Clusiaceae, Cucurbitaceae, Dennstaedtiaceae, Equisetaceae, Fabaceae, Lamiaceae, Mackinlayaceae, Melastomataceae, Meliaceae, Onocleaceae, Oxalidaceae, Piperaceae, Rutaceae, Salicaceae, Styracaceae and Zingiberaceae, each with only one species. By habitus, the greatest number of species have the form of herb with 14 species (32%), whereas the fewest have the form of shrubs with only 5 species (11%). The medicinal plants found in the ecotourism area mostly grow wild in terrain converted by the community into agricultural land, as is the case with *Crassocephalum crepidioides* (Benth.) S. Moore and *Ageratum conyzoides* L., while some are planted by the community for use in

medicine and Gayo ceremonies, for example, *Ruellia simplex* C. Wright. A similar situation applies to gambir, which is cultivated by the Pakpak Bharat community for its pharmacological properties (Rauf et al. 2015).

The most widely used parts of the medicinal plants that we identified are leaves, which were reported to be used by 38% of the species. Several studies have similarly identified leaves as having a relatively high percentage of use (Tantengco et al. 2018; Adam et al. 2020; Assefa et al. 2021; Elfriada et al. 2020; Suwardi et al. 2021). As the sites of photosynthesis, leaves contain nutrients (Supiandi et al. 2019) and a variety of plant secondary metabolites (Zahoor et al. 2017). Beyond that, leaves are easy to find and use, and harvesting them is rarely destructive. Leaves have long been used in herbal medicine in Indonesia (Jadid et al. 2020) and in several other countries such as Vietnam (Nguyen et al. 2019), Ethiopia (Jima and Megersa 2018) and Greece (Tsioutsou et al. 2019). Conversely, flowers and fruits were the plant parts to be used the least, with a percentage of only 2% each.

The raw materials of medicinal plants used by the Gayo community are typically freshly prepared, as is also the case in Ethiopia (Tefera and Kim 2019; Kassa et al. 2020; Abebe and Teferi 2021; Assen et al. 2021; Megersa and Woldetsadik 2022). The community's preference for, if not dependence on, fresh plant parts is due to their reputed efficacy compared with dry plant material, which often has reduced potency (Chaachouay et al. 2022). Even so, exceptions include *Styrax benzoin* Dryand, or frankincense, a plant used in the form of sap by the community not only in traditional medicine but also in various traditional and religious rituals, which reflects its widespread use elsewhere in modern medicine, cosmetics and industry (Jiang et al. 2016; Hu et al. 2017). The Gayo people consider frankincense to be vital in traditional medicine, in which the use of incense is believed to be related to the supernatural. Frankincense is usually burned before and during treatments, traditional ceremonies and religious events.

Based on the IUCN 2022, 11 of the medicinal plant species are listed as "Least Concern", namely *Equisetum ramosissimum* Desf, *Desmodium intortum* (Mill.) Urb, *Persea americana* Mill, *Cinnamomum cuspidatum* Miq, *Centella asiatica* (L) Urban, *Urena lobata* L, *Matteuccia struthiopteris* (L) Tod, *Bischofia javanica* Blume, *Eleusine indica* (L.) Gaertn, *Stachytarpheta jamaicensis* Vahl and *Leea indica* (BURM.f) Merr. On the other hand, *Etlingera elatior* (Jack) R.M. Smith falls into the category of "Data Deficient", while the other plant species are not listed in the IUCN Red List.

Based on the results of the SWOT analysis, there are six strategies for the conservation of medicinal plants in the ecotourism area of Kedah Rainforest Lodges as follow:

Increase the development of adequate support facilities and infrastructure for an educational forest. Such facilities and infrastructure are basic needs for supporting the development of ecotourism, especially in the form of educational forests to be able to attract tourists. The development of tourism infrastructure also contributes to increasing the efficiency of the production and distribution

of tourism services. As a component of tourism competitiveness, investment is an important part of the development of tourism infrastructure which becomes an important factor in tourists' satisfaction (Blazeska et al. 2018). Beyond that, providing an outstanding experience for tourists and facilitating their satisfaction constitutes a major dimension of business performance in ecotourism (Setini et al. 2021). From another angle, more intensive environmental education efforts for both local communities and tourists will positively impact efforts to conserve biodiversity and natural resources. Effective environmental education is not only the transfer of information but also the transfer of the tools needed to develop and enhance environment-related attitudes, values and knowledge as well as hone skills. Such education should prepare individuals and communities to collaboratively execute positive environmental actions that support sustainable environmental conservation efforts (Setini et al. 2021).

Conduct ecosystem rehabilitation to conserve medicinal plants and enhance species population. Rehabilitation should aim to restore the original habitats of the medicinal plants that have been damaged due to conversion into agricultural land by the community. Several methods can be used in rehabilitation efforts, including enrichment planting or planting after the removal of the partial overstorey (Stanturf et al. 2014). Rehabilitation to conserve resources, especially biodiversity, and maintain sustainable use of resources, which provides an ecological experience for travelers, preserve the ecological environment and derives economic benefits (Setini et al. 2021).

Create a mini arboretum and/or medicinal plant greenhouse to conserve medicinal plant species that are becoming difficult to find in the area. Such a strategy aims to protect and maintain medicinal plant species diversity that is becoming difficult to find in their native habitats but has important medicinal benefits. The *in-situ* and *ex-situ* conservation to ensure the presence of priority species remains possible. Stakeholders can play a role in that effort, especially producers of medicinal plant species for sustainable use (Cahyaningsih et al. 2021).

Establish partnerships with local donors, namely the village government, and collaborate with various parties such as FMU, BKSDA Aceh and the private sector in supporting conservation-based area management. To help meet the community's needs for medicinal plants, stakeholders can cooperate in conducting conservation efforts by making village regulations and/or developing a pocketbook on local medicinal plants. In carrying out *in-situ* conservation efforts, the government could introduce laws on how to protect and use medicinal plants and how to promote conservation education by conservationists (Volis 2019). In addition, stakeholders can conduct socialization to increase public knowledge and awareness to maintain the diversity of medicinal plant species. Conservation of medicinal plants can be done by encouraging people not to cut down trees and to plant fast-growing native trees for their household needs (Kadam and Pawar 2020).

Submit funding proposals to government agencies in order to participate in the regional development and preservation of medicinal plant diversity. As in all things,

funding is important in ecotourism management, and support from various parties is needed for a sustainable conservation strategy. Conservation area managers are eager to expand and diversify their funding portfolios by taking into account tourism revenues, which are becoming an increasingly significant fiscal source for the management and conservation of protected areas (Steven et al. 2013). Thus, the management of financial resources is pivotal to obtaining sustainable conservation financing (Setini et al. 2021).

Improve the capacity of human resources of Forest Farmers Group area managers. Such a strategy is essential in the management of the area, where ecotourism is vulnerable to illegal use of the land, such that the area has to be managed properly by competent managers and conservationists. Natural resources in a tourist attraction also have to be managed properly because they are vulnerable to damage with ecological impacts and that interferes with conservation goals (Harahab et al. 2018; Riniwati et al. 2019).

Ecotourism plays an important role in increasing the income of locals, including drivers, guides, caterers and hotel staff (Jacobson and Robles 1992). Ecotourism also plays a role in plant conservation efforts, including those for medicinal plants in the Ubud Monkey Forest, which are promoted as an event to attract tourists. Visitors are even allowed to take certain species of medicinal plants for medicinal purposes. The Ubud Monkey Forest can also be used as the site of educational tours if managers can label each type of medicinal plant in the area to enable teachers, students and guides to recognize and learn the benefits of each medicinal plant (Wijana and Rahmawati 2020). Ethnobotany in conservation areas also shows promise as a source of new product development that can support tourism and collaboration with international pharmaceutical companies and be exported (Ramaano 2021).

At the same time, tourism can also impact the plant species used by the community, as has been the case in Uttarakhand, India. People use medicinal plants for health because they are cheaper and pose few side effects. However, the availability of such drugs faces extinction due to development, rapid population growth, the impact of tourism and deforestation (Dwivedi et al. 2019). As is the case in Kashmir in the Himalayas, tourism activities, grazing, deforestation, urbanisation and transportation have led to a decrease in vegetation, forest cover and soil health, as well as in important phytosociological features of medicinal plant economies (Rather et al. 2022).

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