Ethnobotanical investigation of *Baccaurea* spp. (Phyllantaceae) used by local people near Gunung Leuser National Park, Aceh, Indonesia

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Research

Abstract

Background: Baccaurea spp. is a fruit species that grows in Gunung Leuser National Park and has long been used for food by local communities in the nearby forest. Moreover, several *Baccaurea* spp. are underutilized. Population growth in and near forested areas accelerates forest degradation and threatens the existence of *Baccaurea* spp. in the wild. This study aims to investigate the diversity, use, and role of traditional knowledge in the conservation of *Baccaurea* spp. in Gunung Leuser National Park, Aceh, Indonesia.

Methods: This study was carried out in 12 villages from 6 sub-districts and 4 districts in Aceh province. Extensive field surveys, plant collection, and interviews with local communities were used in this study. The exploration method was used to gather *Baccaurea* spp. samples. Identification of Baccaurea specimens is accomplished through the use of identification keys, comparison with previously identified herbarium specimens, and/or confirmation with relevant taxa experts. Semi-structured interviews with 390 randomly selected respondents were used to collect ethnobotanical data on the use of *Baccaurea* spp.

Results: A total of nine *Baccaurea* spp. were identified, with 90% growing wild in the forest. *Baccaurea polyneura* was the most preferred species for local communities in the study area. Local communities have used *Baccaurea spp.* for different purposes, including food, medicine, construction material, agricultural tools, fodder, and fuelwood. More than 60% of traditional knowledge related to the use of *Baccaurea* spp. was obtained from their relatives.

Conclusion: A total of ten *Baccaurea* spp. were discovered in the study area. *Baccaurea* spp. also plays an important role as a source of medicine, construction material, agricultural tools, fodder, and fuelwood, as well as for food. *Baccaurea* spp., however, in the study area is threatened by several factors, mainly agricultural expansion, implying that conservation efforts should be improved with the implementation of sustainable management strategies based on traditional knowledge that prioritizes Baccaurea species frequently used by local communities.

Keywords: Baccaurea, edible fruit, traditional knowledge, GLNP, Aceh

Abstrak

Latar Belakang: Baccaurea merupakan tumbuhan penghasil buah yang tumbuh di kawasan Taman Nasional Gunung Leuser dan sejak lama telah dimanfaatkan oleh masyarakat sekitar hutan, terutama sebagai bahan makanan. Meskipun demikian, beberapa *Baccaurea* spp. masih belum dimanfaatkan. Pertumbuhan populasi penduduk di sekitar hutan mendorong peningkatan degradasi hutan dan mengancam kelestarian *Baccaurea* spp. di alam. Penelitian ini bertujuan untuk mengkaji keanekaragaman, pemanfaatan, dan peran pengetahuan tradisional dalam konservasi *Baccaurea* spp. di Taman Nasional Gunung Leuser, Aceh, Indonesia.

Metode: Penelitian ini dilakukan di 12 desa dari 6 kecamatan dan 4 kabupaten di Provinsi Aceh melalui survei lapangan, koleksi tumbuhan, dan wawancara dengan masyarakat lokal. Metode eksplorasi digunakan untuk mengumpulkan spesimen *Baccaurea* spp. Identifikasi spesimen *Baccaurea* spp. dilakukan menggunakan kunci identifikasi, perbandingan dengan spesimen herbarium yang telah diidentifikasi sebelumnya, dan/atau konfirmasi dengan ahli taksa terkait. Wawancara semi-terstruktur dengan melibatkan 390 responden yang dipilih secara acak digunakan untuk mengumpulkan data etnobotani tentang pemanfaatan *Baccaurea* spp.

Hasil: Sebanyak 10 spesies *Baccaurea* spp. telah ditemukan di lokasi penelitian, dengan 90% diantaranya tumbuh liar di hutan. *Baccaurea polyneura* merupakan jenis tumbuhan yang paling disukai oleh masyarakat lokal di lokasi penelitian. Masyarakat lokal telah memanfaatkan *Baccaurea* spp. untuk berbagai keperluan, seperti makanan, obat-obatan, bahan bangunan, alat pertanian, pakan ternak, dan kayu bakar. Lebih dari 60% pengetahuan tradisional terkait pemanfaatan *Baccaurea* spp. diperoleh dari orang tua mereka.

Kesimpulan: Sebanyak 10 jenis *Baccaurea* spp. telah ditemukan di lokasi penelitian. *Baccaurea* spp. berperan penting bagi kehidupan masyarakat sekitar hutan terutama dimanfaatkan sebagai makanan, obat-obatan, bahan bangunan, alat pertanian, pakan ternak, dan kayu bakar, serta untuk pangan. Meskipun demikian, *Baccaurea* spp. di lokasi penelitian terancam oleh beberapa faktor, terutama perluasan lahan pertanian, yang menyiratkan bahwa upaya konservasi perlu ditingkatkan melalui penerapan strategi pengelolaan berkelanjutan berbasis pengetahuan tradisional dengan memprioritaskan jenis Baccaurea yang sering dimanfaatkan oleh masyarakat lokal.

Kata kunci: Baccaurea, buah edibel, pengetahuan tradisional, TNGL, Aceh

Background

Gunung Leuser National Park (GLNP) is a conservation area in Sumatra that has been declared a Cultural Heritage Site and a World Network of Biosphere Reserves, with over 4,500 plant species, representing nearly half of all plant species in Indo-West Malaya (Irfan & Priatna 2004). GLNP provides a variety of ecosystem services, particularly non-timber forest products (NTFPs), which have been used by humans since time immemorial for a wide range of purposes, including food, fodder, fiber, traditional medicine, agricultural tools, domestic materials, and construction materials (Navia et al. 2020a; Suwardi et al. 2021; Suwardi et al. 2022a), many of which are associated with cultures (Talukdar et al. 2021). Villagers in forest fringe areas and other rural communities harvest NTFPs to receive income by trading them in the market for a livelihood (Suwardi et al. 2020).

Wild edible foods, including *Baccaurea* spp., are high in vitamins, protein, fat, carbohydrate, and minerals and are essential for subsistence and meeting the sources of daily nutrition and primary health (Vedeld et al. 2007; Li et al. 2016; Talukdar et al. 2021). *Baccaurea sapida* has a high calorific value and minerals, — in particular iron (Pandey et al. 2018), while *Baccaurea pubera* has a high mineral content (Shaharuddin et al. 2021). In addition, *Baccaurea* spp. is frequently used its fruit as a food source and its wood as a building material (Navia et al. 2020). Many *Baccaurea* spp., however, are wild and are considered indigenous and underutilized (Halim *et al.* 2019). These underutilized fruits are usually maintained by cultural preferences and traditional practices, and several of them have been largely neglected in study and conservation. As a result, several *Baccaurea* spp. are categorized as vulnerable (*Baccaurea costulata, Baccaurea glabrifolia, Baccaurea odoratissima*, and *B. purpurea*), and endangered (*Baccaurea carinata*) (Halim et al. 2019).

Population growth near and within forested areas causes rapid forest degradation and biodiversity loss. Habitat destruction, overexploitation, and species introduction have been recognized as significant causes of biodiversity loss worldwide (Mourya et al. 2019). Moreover, there is a trend toward decreasing community interest in local fruit, particularly among the younger generation in rural areas, which can impact the existence of local fruits (Sujarwo et al. 2014; Navia et al. 2020a), including *Baccaurea* spp. Several studies demonstrate that traditional knowledge plays a significant role in the protection of wild plant species (Ajaib et al. 2020; Navia et al. 2021; Adnan et al. 2022) and that the erosion of traditional knowledge can lead to the extinction of these wild species (Sujarwo et al. 2015; Navia et al. 2020b). The aim of this study, therefore, is to investigate the diversity, use, and role of traditional knowledge in the conservation of *Baccaurea* spp. in Gunung Leuser National Park, Aceh, Indonesia.

Materials and Methods

Study area

Aceh Province is located in northern Sumatra, Indonesia, between 01^{0}58'37.2" -06^{0}04'33.6" N; 94^{0}57'57.6" - 98017'13.2" E, with an average elevation of 125 m asl. Aceh Province covers an area of 5,795,600 ha, with more than 50% covered by tropical forests. Aceh province has a total forest area of 3,346,940 ha, with the Gunung Leuser National Park accounting for more than 10% of that total. The average daily air temperature is 25.3 - 27.9^0 C, and the average monthly rainfall is 152.99 mm. Administratively, Aceh is divided into 23 districts, 289 sub-districts, and 6,516 villages. Aceh province has a total population of 5.3 million people, with more than 60% living in rural areas (BPS 2021). This study was carried out in 12 villages from 6 sub-districts and 4 districts in Aceh province (Figure 1).
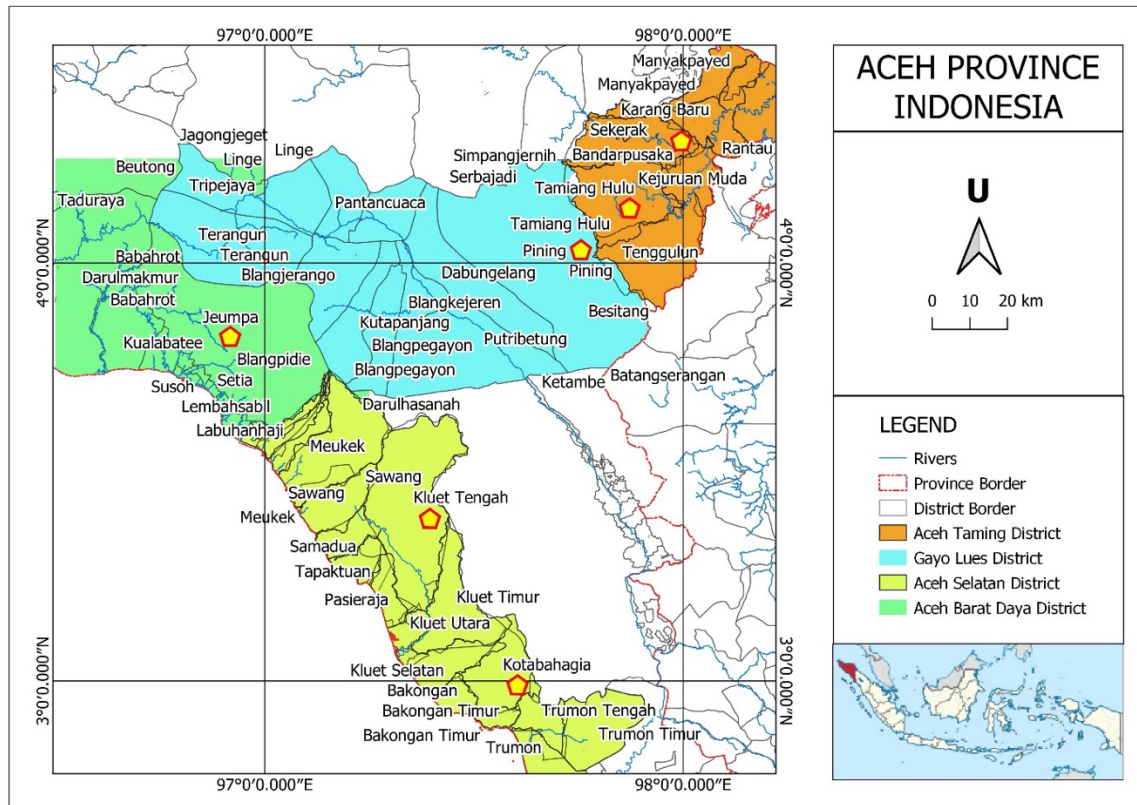

Figure 1. Map of Aceh province, Indonesia. ( ) showing the study area

Data collection

Sample size and respondent selection

Twelve study villages, i.e., Bengkelang, Batu Bedulang, Kaloy, Rongoh, Koto, Malaka, Jambo Keupok, Alur Dua Mas, Alue Sungai Pinang, Alue Rambot, Pintu Rime, and Ekan (Table 1) were selected from a total of 74 villages in six sub-districts based on local authority recommendations, accessibility, and closeness to GLNP.

Table 1. The sample size of respondents from the selected villages

District	Sub-district	Village	No. of population	No. of Households	No. of HH sample
Aceh Tamiang	Bandar Pusaka	Bengkelang	767	172	17
		Batu Bedulang	684	152	15
	Tamiang Hulu	Kaloy	4,914	1,212	123
		Rongoh	1,082	290	29
Aceh Selatan	Kluet Tengah	Koto	1,316	401	41
		Malaka	736	169	17
	Kota Bahagia	Jambo Keupok	1,111	305	31
		Alur Dua Mas	1,044	270	27
Aceh Barat Daya	Jeumpa	Alue Sungai Pinang	1,913	436	44
		Alue Rambot	668	152	15
Gayo Lues	Pining	Pintu Rime	557	145	15
		Ekan	520	143	14
Total			**15,312**	**3,847**	**390**

To ensure a representative sample for the 12 villages, the sample size was determined using Cochran's sample size formula as presented by Bartlett et al. (2001).

$$n = N/1 + N(e)^2$$

where n is the study sample size, N is the total number of populations in all 12 selected villages, e is the maximum variability or margin of error of 5% (0.05), whereas 1 is the probability of the event occurring. As a result, the total sample is as follows:

$$n = 3,847/1 + 3,847 \ (0.05)^2, \ n = 390$$

The sample size for each village was determined based on the proportion of the households in the respective villages. For example, the total number of households in Bengkelang was 172, yielding a number of 17 (n = 390 x 172/3,847 = 17). The same calculation was performed for the other villages.

Data gathering and plant identification

This study included 390 respondents ranging in age from 15 to 75 (Table 1) who were chosen at random from twelve villages. Semi-structured interviews, guided field walks, and field observation were used in data collecting. The interview focused on the diversity and uses of *Baccaurea* spp., such as What *Baccaurea* spp. have been discovered in this area? How they discovered these plants could be eaten? What else can *Baccaurea* spp be used for besides food? Which plant is preferred? What are your personal opinions on the main threats of *Baccaurea* spp? etc. For ethical reasons, ethnobotanical data were gathered in the presence of local administrators and with the permission of each respondent for the research's publication.

Plant samples were gathered. The voucher specimens were identified in Herbarium ANDA, Universitas Andalas, West Sumatra, Indonesia. Identification of Baccaurea specimens is accomplished through identification keys and comparison with previously identified herbarium specimens. The Tropicos database (https://www.tropicos.org/) was used to update the botanical name.

Data analyses

Descriptive statistics, relative frequency citation, respondent consensus factor, and preference ranking were used to analyze the data. Microsoft Excel spreadsheets were used to organize ethnobotanical data.

The Relative Frequency Citation (RFC) index was calculated following Vitalini et al. (2013):

$$RFC = FC/N$$

RFC calculates each species' local importance by dividing the frequency of citation (FC) by the total number of respondents in the study (N), ignoring use categories.

The *Baccaurea* spp. preference ranking activities were carried out following Martin (1995). All respondents were asked to rank the preferred *Baccaurea* spp. in terms of taste quality. The most preferred value was five, and the least preferred value was one. Finally, the total scores were added and ranked to determine the most preferred *Baccaurea* spp.

Results

Demographic profile of the informants

A total of 390 respondents were interviewed during this study, most of them are women (58.46%) between the ages of 36 and 45 years. The majority of informants had a Senior level of education (34.87%), while the percentages of other levels (Junior, Elementary, no education, and University,) were 26.41%, 23.85%, 11.28%, and 3.59%, respectively (Table 2).

Diversity, habitats, and abundance of *Baccaurea* spp. in the study area

In this study, wild edible plants were collected from the home garden, farmland, and forests. The majority (90 %) of *Baccaurea* spp. that the communities reported were collected from the forest. *Baccaurea* spp. was most commonly found in the Aceh Barat Daya district with 9 species, followed by Aceh Selatan (7 species) and Gayo Lues and Aceh Tamiang with 6 species each (Table 3).

Table 2. Socio-demographics of respondents

	Variable	Total	Percentage (%)
	Men	162	41.54
	Women	228	58.46
Age	15-25	59	15.13
	26-35	74	18.97
	36-45	92	23.59
	46-55	88	22.56
	56-65	60	15.38
	66-75	17	4.36
Education	No Education	44	11.28
	Elementary School	93	23.85
	Junior High School	103	26.41
	Senior High School	136	34.87
	University	14	3.59

Table 3. Diversity, status, habitats, and distribution of *Baccaurea* spp. in the study area

Scientific name	No. of individuals	Habitat	Status	Study area			
				Aceh Selatan	Aceh Barat Daya	Gayo Lues	Aceh Tamiang
Baccaurea brevipes Hook. f.	58	Forest	Wild	√	√	√	√
Baccaurea deflexa Müll. Arg.	8	Forest	Wild	√	√	-	-
Baccaurea lanceolata Müll. Arg.	18	Forest	Wild	√	√	√	√
Baccaurea macrocarpa Müll. Arg.	12	Forest	Wild	√	√	√	√
Baccaurea macrophylla (Müll. Arg.) Müll. Arg.	4	Forest	Wild	√	-	-	-
Baccaurea parviflora (Müll. Arg.) Müll. Arg.	64	Forest	Wild	√	√	√	√
Baccaurea polyneura Hook. f.	14	Forest, farmland	Wild	√	√	√	√
Baccaurea racemosa (Reinw. ex Bl.) Müll. Arg.	2	Forest	Semi-cultivated	-	√	-	-
Baccaurea ramiflora Lour.	7	Forest	Wild	-	√	√	√
Baccaurea sumatrana (Miq.) Müll. Arg.	4	Forest	Wild	√	√	-	-

Use diversities of *Baccaurea* spp. collected from the study area

All ten *Baccaurea* spp. identified in the study area were harvested and consumed by local communities. *Baccaurea polyneura* is frequently consumed by the local community in the study area (RFC = 0.94), followed by *Baccaurea macrocarpa* (0.77), *Baccaurea deflexa* (0.58), and *Baccaurea racemosa* (0.53) (Figure 2).

The fruit is the most commonly consumed plant part. The majority of Baccaurea fruits are sweet. *Baccaurea lanceolata*, on the other hand, has a sour taste. Approximately 46% of respondents said they would further process this fruit as a salad or by dipping it in sugar or salt. Moreover, 28% of participants mentioned that *B. lanceolata* fruit is commonly processed further by being cut into small pieces, sun-dried, and used in food preparation ingredients.

B. polyneura is the most popular fruit, cited by the majority of respondents. Due to their pleasant taste, the fruits were the most preferred by local communities in the study area (preference ranking; Table 4). Aside from food, *Baccaurea* spp. has several other uses, such as medicine, construction material, agricultural tools, fodder, and fuelwood (Table 5).

Traditional knowledge transmission

The most of traditional knowledge of the *Baccaurea* spp. was reported to be transmitted from relatives (grandparents and parents), followed by friends/neighbors, school, and some people who claimed to have learned about the use of *Baccaurea* spp. on their own by surfing the web. The distribution of the main sources of knowledge by gender, age class, and education level is shown in Figure 3.

Figure 2. *Baccaurea* spp. in the study area. (A). *Baccaurea polyneura*, (B). *Baccaurea macrocarpa*, (C). *Baccaurea lanceolata;* and (D). *Baccaurea parviflora*
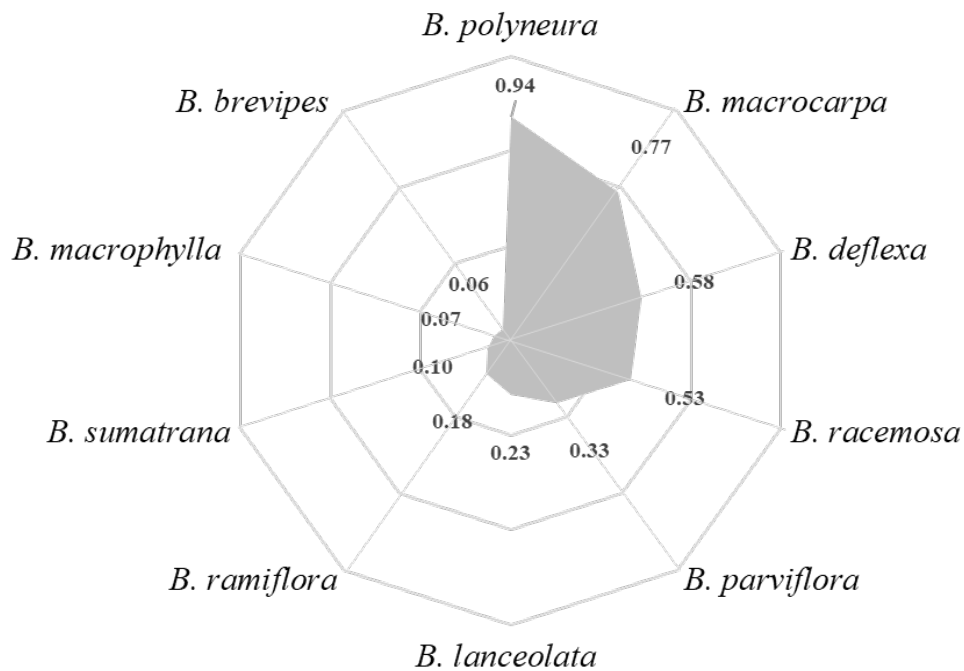
Figure 3. *Baccaurea* spp. with the highest Relative Frequency Citation (RFC)

Table 4. Results of preference ranking of *Baccaurea* spp. by their taste quality (1 = least, 5 = excellent)

Scientific name	Respondents (N = 390)												Average Score	Rank
	BE	BB	KA	RO	KO	MA	JK	AD	AS	AR	PR	EK		
B. polyneura	4.8	5	4.8	5	5	4.8	5	5	4.8	5	4.8	5	4.9	1st
B. macrocarpa	4.8	4.6	4.4	4.6	5	4.6	4.6	4.8	4.4	4.8	4.8	4.6	4.7	2nd
B. deflexa	-	-	-	-	4.8	4.8	4.2	4.6	4.4	4.4	-	-	4.5	3rd
B. parviflora	4.2	4.4	3.8	4.2	4.6	4.2	4.2	4.8	4.6	4.8	4.8	4.4	4.4	4th
B. lanceolata	4.4	4.2	4.2	4.4	3.2	4.8	4.4	4.2	4.2	4.4	4.2	4.2	4.2	5th
B. racemosa	-	-	-	-	-	-	-	-	4.2	3.8	-	-	4.0	6th
B. ramiflora	4.4	3.8	3.8	4.2	-	-	-	-	4.2	3.8	3.6	4.2	4.0	7th
B. sumatrana	-	-	-	-	3.2	3.8	3.8	3.4	3.4	3.8	-	-	3.6	8th
B. brevipes	2.8	3.2	3.2	2.6	3.2	3	2.8	2.8	2.6	2.8	2.8	3.2	2.9	9th
B. macrophylla	-	-	-	-	2.2	2.6	3.2	2.6	-	-	-	-	2.7	10th

Note: BE = Bengkelang; BB = Batu Bedulang; KA = Kaloy; RO = Rongoh; KO = Koto; MA = Malaka; JK = Jambo Keupok; AD = Alur Dua Mas; AS = Alue Sungai Pinang; AR = Alue Rambot; PR =Pintu Rime; EK = Ekan

Table 5. *Baccaurea* spp. for the different use categories in the twelve villages of the study area

Scientific name	Use Categories											
	BE	BB	KA	RO	KO	MA	JK	AD	AS	AR	PR	EK
B. brevipes	F, T	F	F	F, T	F	F	F, T	F	F, M	F, M, T	F, D	F, T
B. deflexa	-	-	-	-	F	F, T	F	F	F	F, T	-	-
B. lanceolata	F, M, D	F	F	F	F	F, M	F	F	F	F	F, T, M	F
B. macrocarpa	F	F, T, W	F	F	F, W	F	F	F	F, M	F	F, W	F, M
B. macrophylla	-	-	-	-	F	F	F, W	F	-	-	-	-
B. parviflora	F	F	F	F	F	F	F	F	F, T, D	F, T	F, T	F
B. polyneura	F, C, T, W	F, W	F, W	F, W	F, W	F	F, T, D	F, W	F, W	F	F	F
B. racemosa	-	-	-	-	-	-	-	-	F, M, D	F, D, W	-	-
B. ramiflora	F	F	F, T	F	-	-	-	-	F	F	F	F
B. sumatrana	-	-	-	-	F	F	F	F	F	F	-	-

Note: **Village**: BE = Bengkelang; BB = Batu Bedulang; KA = Kaloy; RO = Rongoh; KO = Koto; MA = Malaka; JK = Jambo Keupok; AD = Alur Dua Mas; AS = Alue Sungai Pinang; AR = Alue Rambot; PR =Pintu Rime; EK = Ekan; **Use Categories**: F = Food; M = Medicine; C = Construction; T = Agricultural tools; D = Fodder; W = Fuelwood

More than 60% of respondents said that their parents were the most important source of information. During the discussion, the young women admitted that they learned this knowledge visually and verbally while cooking with their mothers or grandmothers. Approximately 18% of respondents said they learned about the use of *Baccaurea* spp. from friends, neighbor, or their teachers at school. Following their traditional knowledge, approximately 38% of respondents reported planting *B. polyneura* combined with crops on their land farm to ensure the fruit's availability for food and economic purposes.

Threats to *Baccaurea* spp.
Several factors, including land use, habitat destruction, and overharvesting, were identified as threats to *Baccaurea* spp. in the study area. Agriculture expansion, forest fire, timber harvesting, fruit harvesting, and fuelwood collection were severely depleting *Baccaurea* spp. in the study area. Among these problems, most respondents perceived that agricultural expansion was the main factor that threaten *Baccaurea* spp. (Figure 4).

Discussion

A total of ten *Baccaurea* spp. were found in the study area, with 90% of species discovered growing wild in the forest. The fruits of this species have been harvested and consumed fresh without further processing. This study is consistent with those reported by Navia et al. (2021) in North Aceh, Indonesia. *B. polyneura* is the most preferred fruit consumed by local communities in the study area. This fruit is reported to possess a high of important nutrients, including carbohydrates, protein, fats, vitamins, and minerals (Suwardi et al. 2022b), essential to support activity, growth, and human health. Furthermore, there are *Baccaurea* spp. that are disliked because of their sour taste, such as *B. lanceolata*, but people in the study area have utilized the fruit part to treat flu, stomach che, diarrhea, and hypertension. *B. lanceolata* contain bioactive compounds such as phenols, flavonoids, anthocyanins, and carotenoids (Bakar et al. 2014), which have pharmacological effects and play an important role in supporting rural community health. Moreover, *B. lanceolata* fruit is high in antioxidants (Bakar et al. 2014), which are essential in preventing degenerative diseases (Hamid et al. 2010). Other species, such as *Baccaurea ramiflora*, have fruit that is used to treat indigestion and food, and the leaves are used as an antidote for centipede bites. Flavonoids, alkaloids, saponins, and phenolic compounds are abundant in fruits and leaves (Najda et al. 2014; Tantengco et al. 2018) and may be responsible for the pharmacological effects observed by the local people.
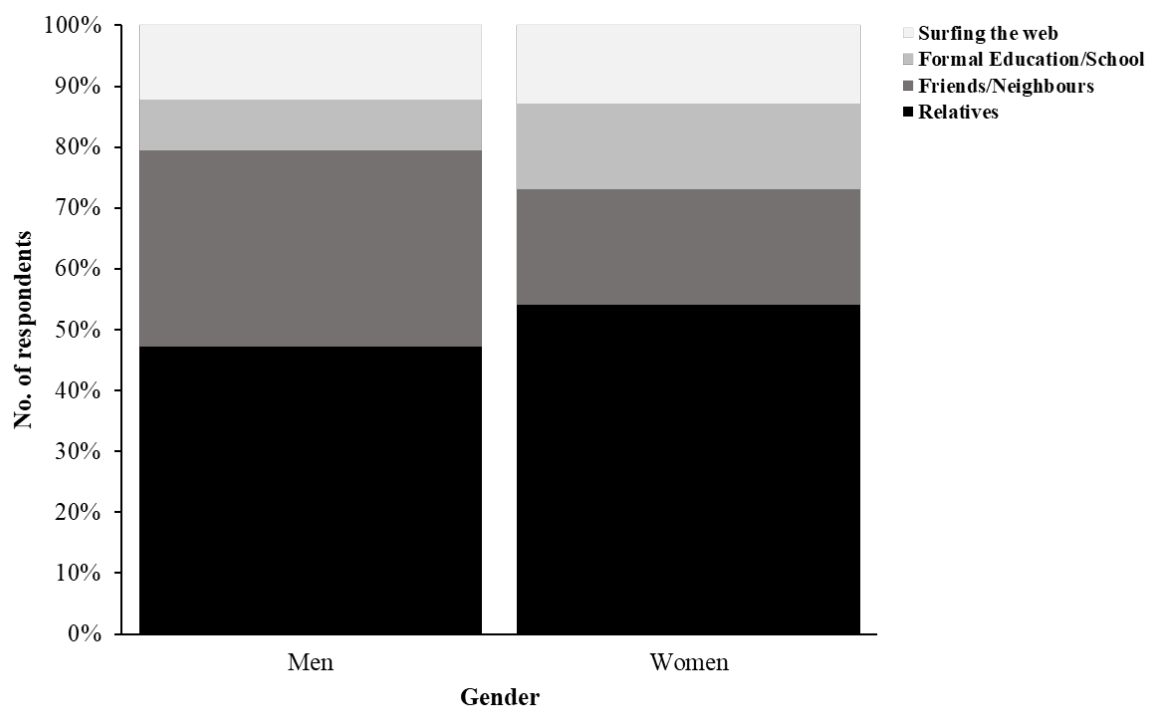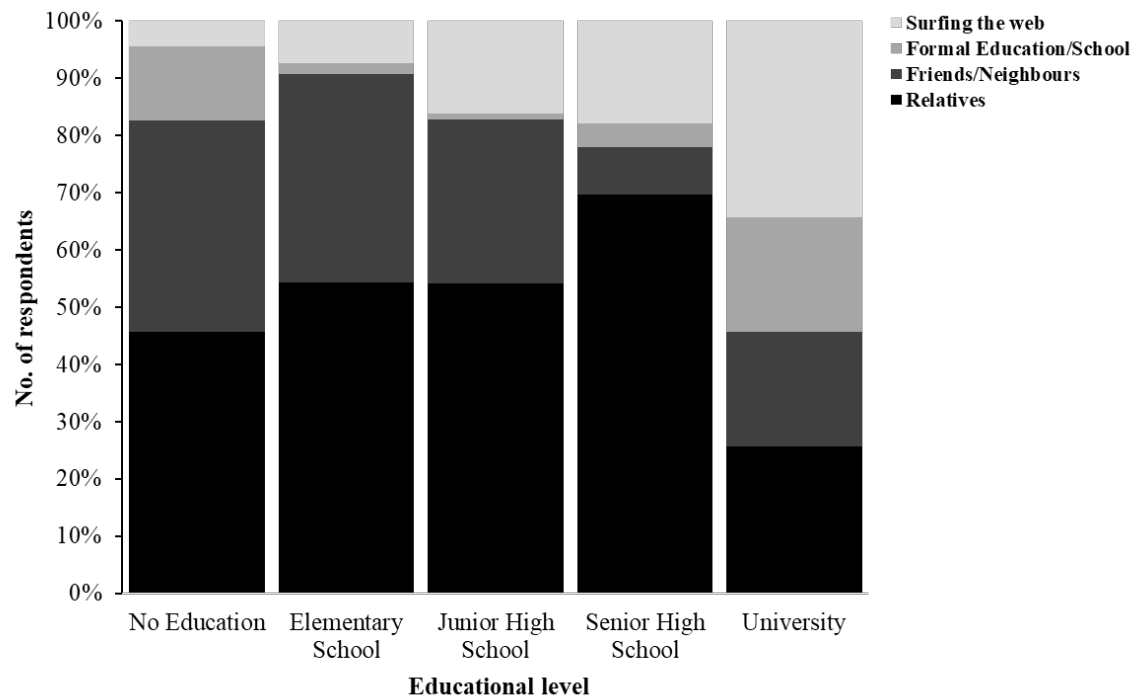
(A)

Figure 4. Distribution of four different information sources that people used to learn how to use *Baccaurea* spp. based on (A) gender.
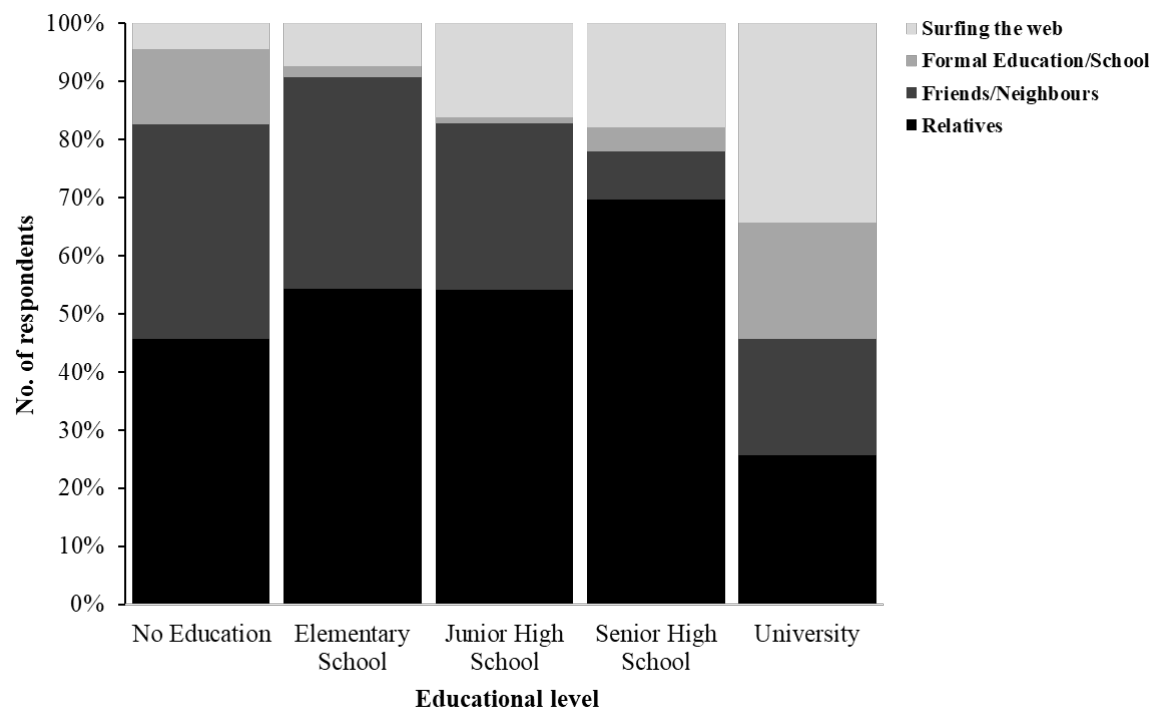
(B)

(C)

Figure 4. Distribution of four different information sources that people used to learn how to use *Baccaurea* spp. based on (A) gender, (B) age group, and (C) Educational level
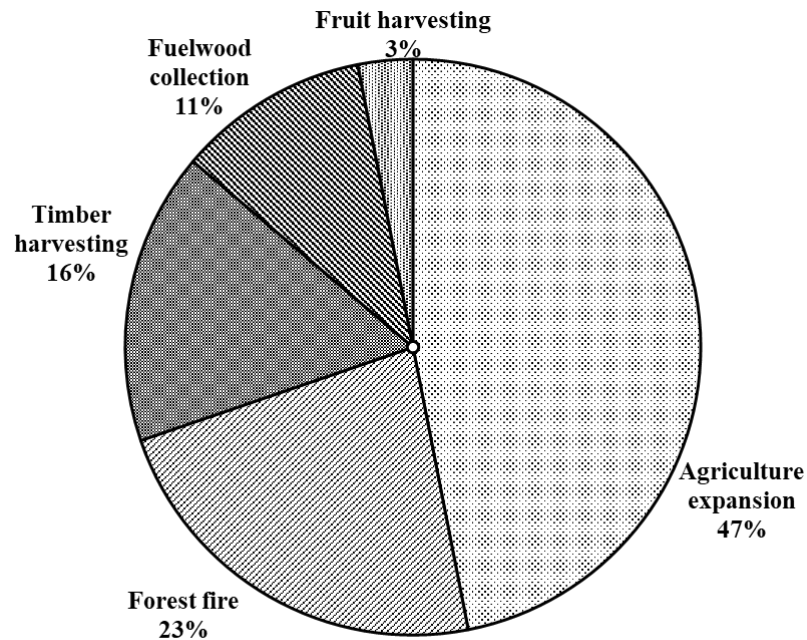
Figure 5. The local community's perception of activities is considered to be a major threat to *Baccaurea* spp.

The use of *Baccaurea* spp. has long been practiced by rural communities in the study area. *Baccaurea* spp. is used for various purposes, including food, medicine, construction material, agricultural tools, fodder, and fuelwood. Local people are also aware of a wide range of biodiversity uses, as evidenced by their knowledge of habitat preferences, life histories, and behavior related to efficient foraging for such resources (Mekonen et al. 2017). This knowledge has been passed down through generations. The majority of their knowledge on the use of *Baccaurea* spp. emerged from their relatives, with the rest coming from friends, neighbors, or formal education (school). Local people frequently have a broad understanding of the behavior of complex ecological systems in their communities, as well as a historical continuity of resource-use practices (Mekonen 2017). Local people in the study area have implemented local conservation efforts for *Baccaurea* spp. following their traditional knowledge, such as *B. polyneura* planted in their farmlands, to protect it from extinction and ensure its availability in the future. The relationship between biological and cultural diversity has become a compelling reason for local communities to involved in biodiversity conservation. Local ecological knowledge must be considered and fully integrated into management and conservation plans (Ca´mara-Leret et al. 2014). Documenting traditional knowledge, on the other hand, is necessary for response to a decrease in traditional knowledge in the future.

Conclusions and recommendations

This study provides essential information on *Baccaurea* spp. used by local communities near Gunung Leuser National Park, Aceh province, that could be used as part of a natural resource management strategy. The findings are based on the social perceptions of local communities that reported on the current use of the species identified in the study area. A total of ten *Baccaurea* spp. were discovered in the study area. The most preferred species for local communities in the study area were *B. polyneura*. *Baccaurea* spp. also plays an important role as a source of medicine, construction material, agricultural tools, fodder, fuelwood, and food. *Baccaurea* spp., however, in the study area is threatened by several factors, mainly agricultural expansion, implying that conservation efforts should be improved with the implementation of sustainable management strategies based on traditional knowledge that prioritizes Baccaurea species frequently used by local communities.

Declarations

Ethical approval and consent to participate:
Permission was taken from the subdistrict head of Bandar Pusaka, Tamiang Hulu, Kluet Tengah, Kota Bahagia, Jeumpa, and Pining prior to data collection. Oral agreements were obtained from local respondents and all field data were collected through their oral approval.
Consent for publication: Not applicable.
Conflict of interests: The authors declare no competing interests
Availability of data and materials: Data will be available from the corresponding author in a special request.

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