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EDITED BY
Archna Singh,
All India Institute of Medical Sciences, India

REVIEWED BY
Saiful Irwan Zubairi,
National University of Malaysia, Malaysia
Jayanta Kumar Patra,
Dongguk University Seoul, Republic of Korea

*CORRESPONDENCE
Rachel Thomas Tharmabalan
✉ rachthomas777@gmail.com

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Identification of wild edible plants used by the Orang Asli, indigenous peoples of the Malay Peninsula

Rachel Thomas Tharmabalan[1,2]*

[1]School of Ethnic Studies, Bangi, Malaysia, [2]Division of Natural Resource Economics, Graduate School of Agriculture, Kyoto, Japan

Background: This research focused on the different varieties of wild edible plants (WEPs) actively utilized by the Orang Asli of Malaysia and their medicinal values. The Orang Asli have been relying on these plants for their sustenance and wellbeing. However, with environmental degradation, many of these wild edibles are slowly becoming sparse, which then has a spillover effect and has resulted in the erasure of knowledge. Therefore, this research paper also aims to highlight the naming system utilized by the Orang Asli, the gender/age gap and the medicinal properties of these wild edible plants.

Methods: This research was conducted to identify the important wild edibles used among the Orang Asli, using both semi-structured and field interviews, as well as ethnobotanical appraisal methods. With the assistance of 24 informants, a total of nine wild edible plants were identified based on their importance as food and medicine for the Orang Asli groups in three different Semai settlements.

Results and discussion: From the results obtained, the wild edibles identified in the study have potential medicinal value and have been used by the Orang Asli for many generations. Also, based on my results, older Orang Asli can potentially serve as a repository of knowledge of wild edible plants within their settlements, as they were more informed than young people. However, there is little remaining knowledge of their medicinal uses in Telimau; elder women retain more knowledge than elder men in Bukit Terang, and the greatest knowledge retention for both young and old is seen in the more remote settlement of Kampung Sat.

Conclusion: This research documents the medicinal uses of these wild edibles, and may provide a starting point for further studies on these species and encourage conservation initiatives, in addition to helping safeguard the indigenous knowledge and the distinct cultural identities of the Orang Asli.

KEYWORDS

indigenous people, Orang Asli, wild edible plants, Malaysia, ethnobotany

1. Introduction

Malaysia's tropical rainforests are thought to be one of the world's oldest, dating back 130 million years. Wild edible plants (WEPs), as described by the Food and Agriculture Organization, are "plants that grow spontaneously in self-maintaining populations in natural or semi-natural ecosystems and can exist independently of direct human action" (Heywood, 1999). However, to date, there is little agreement among researchers and policy makers on the precise definition of WEPs and how these plants should be defined. Here, they are described as plant species that have not been formerly categorized as major crops, have previously been neglected, under-researched, presently have low levels of application and utilization, and are mostly limited to rural and remote areas. Globally, rural communities are the main consumers and agents of preservation

for underutilized and neglected plants. They often serve as defenders of lost botanical knowledge, as the mastery and categorization of these plants is often locked up in indigenous knowledge.

The racial composition of Malaysia is made up predominantly of three ethnic groups. Each ethnic group possess their own version of traditional ethnomedicinal systems and to varying degrees have been associating with different plants their entire lives. The Orang Asli make up only 0.7% of the Malaysian population, and about half of the Orang Asli are Semai. The other two groups are the Semang (in the Northern part of the Peninsula) and the "Proto-Malay" in the Southern region. They have been interacting with the environment from the time they settled in the peninsula (roughly around 8,000 to 10,000 years ago) and have been living respectfully with the land whilst accumulating an in-depth body of knowledge from its surrounding. As mentioned by Toshihiro (2009); many of the Orang Asli practices have been adopted and modified by the dominant population particularly for medicinal applications, decoration of houses, religious uses, and nourishment. Here, I will focus on the Semai group which is part of the broader Senoi category living in the central region of the peninsula, and is the largest single aboriginal ethnic group at ∼49,697 in 2010 (Masron et al., 2013).

The Semai live mostly in the States of Perak, Pahang, and Kelantan and Selangor; they practice an egalitarian lifestyle, and have recently stopped practicing shifting ("slash and burn") cultivation. With the goal of suppressing growing interest in the Communist party among indigenous peoples, and as a gesture of support for their economic development, the government has relocated indigenous families and provided year-round housing estates with electricity, running water, and schools (Hamdan, 2016). Changes of this kind increase the likelihood that traditional uses of wild plants will be lost. According to a genetic analysis conducted by the National University of Singapore, the Semai are closely related to the Khmer of Cambodia (Hays, 2015); according to Saha et al. (1995), the Senoic language spoken by the Semai is a subgroup of the Mon Khmer languages. Similarly, Benjamin (1973) has claimed that the Senois are from Cambodia, Vietnam, and Burma's mountainous regions. Even to this day, though many are no longer living in remote areas, they have, to some degree, managed to preserve their customs and beliefs in a way that is still connected to the land. However, due to the weak law enactment and enforcement of the Aboriginals People Act in regard to customary ownership of their land, much of their traditional territories have been taken over by the government, and the traditional rights to forage have gone away with it (Zainuddin, 2012).

As a result, it is imperative to document the wild edible plants utilized by the Orang Asli before the knowledge associated with it is lost, as well as to ensure the preservation of the plant gene pool. The culture of the Orang Asli could also be safeguarded as they have been relying on these wild edibles as a source of food, medicine, and building materials since time immemorial. It is hypothesized that the older Orang Asli women are more knowledgeable than male elders or other Orang Asli when it comes to identifying wild edibles as well as the medicinal value associated it. Also, the Orang Asli clearly possess a significant corpus of traditional knowledge on wild edible plants, which can be validated by science, particularly in relation to medicinal properties. However, due to the rapid encroachment of modernization, there is an erosion of knowledge among the younger generation.

2. Methodology

The study was conducted in settlements in both Pahang and Perak; most Semai live in the latter, however some Orang Asli villages lie on the borders of the neighboring state, Pahang. There are also some Semai communities in Selangor and Kelantan. Three settlements were chosen for study: Telimau, Bukit Terang, and Kampung Sat (see Figures 1, 2). The indigenous people from all three villages were from the Senoi tribe, and eight people was selected from each village. The informants selected spoke fluent Malay, which allowed for easier communication as majority are bilingual. Telimau is located at an altitude of 3,349 feet in the Cameron Highlands district and has a mean precipitation of 2,600 mm per year (Chan, 2000). The Highlands are known for their diverse natural resources and are also home to many rare flora and fauna, some of which may become vulnerable or endangered in the future. The settlement in Kampung Sat is deeper in the jungle than Telimau and Bukit Terang. Bukit Terang and Kampung Sat have a mean rainfall of 999.9 mm. Telimau's location is 4°31′46"N 101°28′18"E whereas Bukit Terang's geographical coordinates are 2°45′0"N, 102°10′51"E. Kampung Sat's coordinates are 4°0′0"N, 101°18′36"E. While all three villages are located near rivers, the rivers in Telimau and Bukit Terang are turbid and muddy as a result of soil erosion caused by deforestation in those areas. With less environmental disturbance and pollution in its surroundings, rivers in Kampung Sat, which is situated deeper in the forest, are less polluted.

2.1. Population method

There were 24 informants who contributed to this study; they included 9 "key" informants and 15 "ordinary" informants (Table 1). Of the key informants, five were male and four female; the ordinary informants included seven male and eight female contributors. Each village was represented by eight informants out of which three are key informants. The distinction between key and ordinary informants is that the former were still active practitioners, recognized by members of the community as holding an in-depth knowledge of the utilization and medicinal values of WEPs; in contrast, the ordinary informants do not engage with their knowledge on an everyday basis, but have sufficient knowledge of WEPs. To gain further understanding of the rate of knowledge transmission within the community as well as the extent of the erosion of knowledge, the informants ages ranged in age from 25 to 70 years old. This also allowed the researcher to evaluate the homogeneity and heterogeneity of their indigenous knowledge.

According to a study by Hennink et al. (2017), 16–24 interviews are needed to attain meaning saturation, at which point researchers could create a richly detailed understanding of issues and nine interviews were needed to indentify thematic issues. Due to the limited number of active practitioners in each community, nine key informants and 15 ordinary informants were selected across three settlements to make up the 24 interviews based on the parameters needed to guide sample sizes.

A non-random sampling method was chosen as this research study spans across three settlements. The purposive sampling technique allows the researcher to select informants based on a certain condition to accomplish the research's primary objective (Etikan et al., 2016). I deliberately selected key informants who

FIGURE 1
Area of study.

were still actively practicing traditional knowledge, and engaging in hunting and gathering activities to various extents. The snowball sampling method was used together with the purposive sampling technique as it is cost and time effective, well-structured and allows for improved communication as the secondary informants are close contacts with the primary informant (Polit and Beck, 2006). With the help of a volunteer, and the Orang Asli helper, the researcher met with the village headman. The researcher first visited the headman of each settlement, to discuss the research objectives and methods of inquiry that would be used for this research. For the subsequent visit the headman helped identify a few potential key informants. The researcher then met with the informants to explain the purpose of the study, the roles of the informants and to further clarify how their confidentiality would be maintained.

Three main criteria were used when recruiting potential key informants, based on their skill as (1) traditional experts of wild edible plants and presently medicating community members who are ill, (2) their competency and ability to identify these wild edibles and providing comprehensive details about their usage, parts of the plant used for food or medicine, medicinal properties, and taboos associated, and (3) whether they were old enough to recognize and have experience of the effects of cultural assimilation in their settlements. Although the ordinary informants were younger, they were also committed practitioners, though they did not generally deal with indigenous expertise on a daily basis. As a result, the researcher was able to assess the depth of their knowledge in regards to the environs and WEPs. Before embarking on this research, all participants were briefed and assured that they could choose to be a part of this research or withdraw at any time. The researcher also emphasized that prior consent would be obtained before utilizing any information, pictures of participants or interview excerpts that might form part of the final output. For the older generation, who were mostly illiterate, to obtain their formal written permission the researcher explained all key elements verbally in detail before asking them to sign if they were interested in participating. Also, The Code of Ethics of the Society of Ethnobiology was observed, thus ensuring that the many rights recorded are recognized, respected and followed in this research paper (International Society of Ethnobiology, 2006).

After the interview with the first key informant identified by the headman of the village, that informant provided the names of a few other potential participants following the standard protocols of the snowball sampling technique. The same was done with other key informants. Eventually, from the list of names given, the researcher then initiated contact with other potential informants to help finalize the list of candidates that met the three research criteria. This approach helped to develop consistent results by reducing any variance that might occur and ensuring that any similarities were emphasized. The final 24 informants who were chosen had many, if not all, the key attributes outlined in the paragraph above, as they were able not only to help recognize plants, but were also applying their traditional knowledge and customs.

The interviews were carried out in Bahasa Melayu (the Malay language) and an Orang Asli translator was present in case the need might arise. Field notes were also taken, along with records of the wild edible plants' habitat, local name, key determining attributes, and features to assist with accurate (subsequent) identification. These wild edible plants were then later identified at the herbarium of Universiti

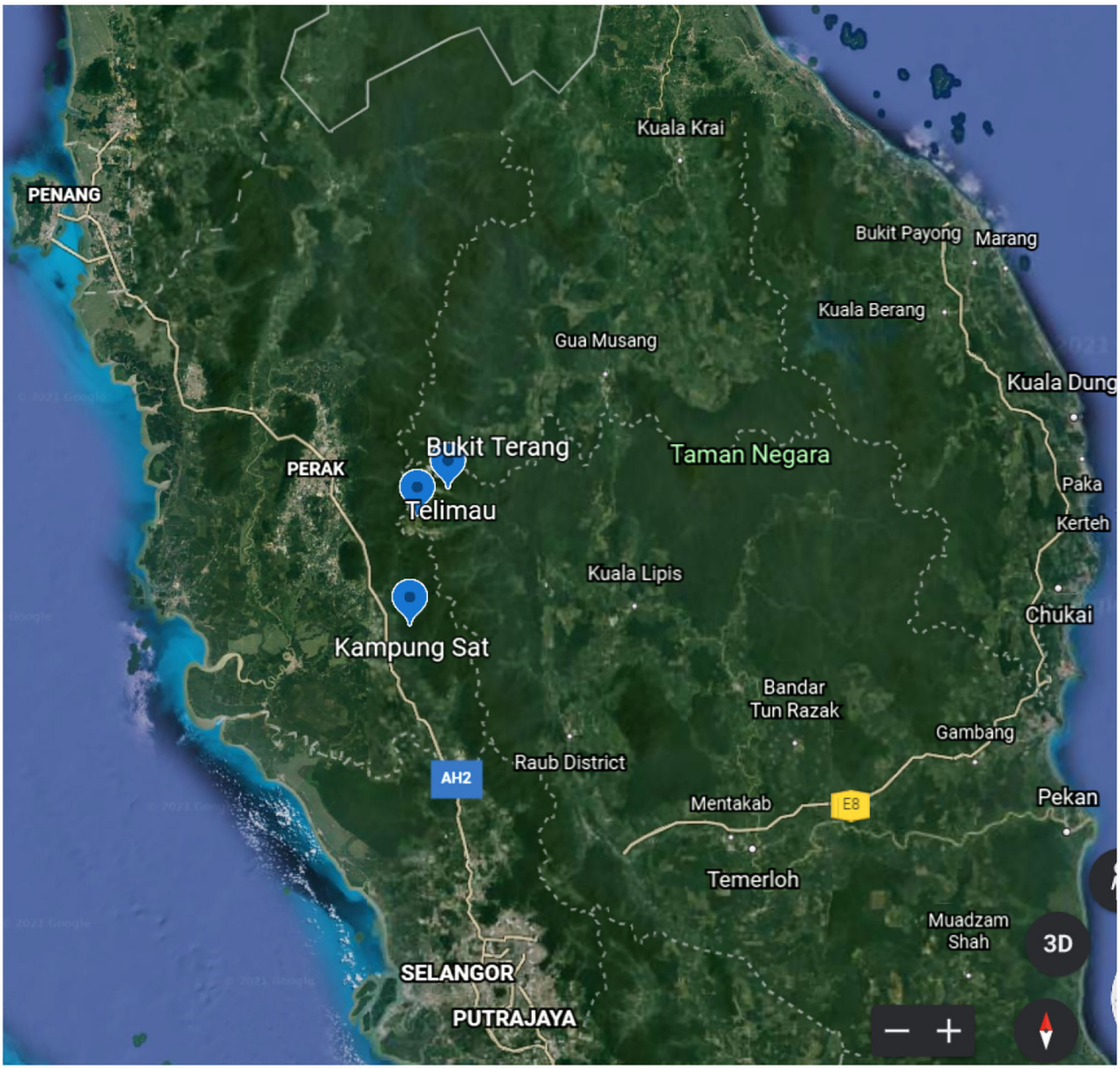

FIGURE 2
Map showing the location of Telimau, Bukit Terang, and Kampung Sat.

Kebangsaan Malaysia. The Tropicos taxanomic database was used to help confirm the plant names.

2.2. Sample collection

After the interview sessions were conducted, further samples of the wild edible plants were gathered for identification, using the standard guidelines documented by Cheah (2004) for species conservation. Three samples of fresh wild edible plants were harvested and pictures of their locations were immediately taken. The plant specimens were then packed in food grade plastic bags and transported to the herbarium at Universiti Kebangsaan Malaysia for identification. Relevant details, such as location, habitat, and local plant names were also documented, along with photographs showing their morphological characteristics.

Statistical analysis was not conducted on the data obtained as there were only 24 key informants and only nine wild edibles identified in this study. Hoffman and Gallaher (2007) reported that for statistics to be applied on ethnobotanical data, at least 35 independent informants would be required; for this reason formal statistical analysis could not be made of this data set.

3. Results

Nine wild edible plants were identified based on their importance and frequency of consumption by the Orang Asli groups located in the three different villages (Telimau, Bukit Terang, and Kampung

TABLE 1 Participant information.

Informant	Village	No. of reports	Sex	Marital status	Age
Informant 1 (key)	T	4	M	M	57
Informant 2 (key)	T	2	F	M	36
Informant 3	T	1	F	S	22
Informant 4 (key)	T	2	M	M	56
Informant 5	T	0	F	M	28
Informant 6	T	1	M	S	32
Informant 7	T	3	F	M	31
Informant 8	T	1	M	M	47
Informant 9	BT	2	F	M	35
Informant 10 (key)	BT	5	M	M	68
Informant 11 (key)	BT	11	F	M	67
Informant 12 (key)	BT	9	F	M	70
Informant 13	BT	4	F	M	40
Informant 14	BT	1	M	M	33
Informant 15	BT	0	M	M	29
Informant 16	BT	1	M	M	37
Informant 17	BT	6	M	M	41
Informant 18	BT	9	F	M	31
Informant 19	KS	6	F	M	30
Informant 20	KS	2	M	S	22
Informant 21 (key)	KS	7	M	M	56
Informant 22	KS	19	F	M	54
Informant 23 (key)	KS	16	F	M	62
Informant 24 (key)	KS	9	M	M	58

Village of origin is identified as: Telimau (T), Bukit Terang (BT), or Kampung Sat (KS).

Sat). Table 2 summarizes the scientific, local, Malay, Chinese, and English vernacular names of each plant, and the family to which each plant belongs. It also indicates whether it is known in one or more of the three villages, and whether the species is native to the region, or introduced. In Table 3, for each species, the number of times it is cited by respondents (out of a total maximum of 24) and the local medicinal uses are listed. All of the wild edible plants identified in this study are primarily used as food and secondarily as medicine.

Six of these nine plants grow in the wild, and can be found relatively easily within the confines of the settlement. *Sauropus androgynus* (L.) Merr. and *Manihot esculenta Crantz*, though growing in the wild, are also cultivated in both Telimau and Bukit Terang, whereas *Solanum nigrum L.* is only cultivated in Telimau.

In Kampung Sat, all these plants are collected from the nearby jungle. Four of these nine wild edibles are introduced species that have become naturalized, while the remaining five are native to the region. Of the nine wild edibles, four (*Sauropus androgynus*, *Manihot esculenta*, *Diplazium esculentum,* and *Gomphandra quadrifida* are used by pregnant Orang Asli women either to induce labor, increase lactation or as a stimulant to recover vitality and energy after delivery. To help cure skin disease and injuries, the Orang Asli reported that, *Pleocnemia irregularis*, *Diplazium esculentum,* and *Strobilanthes crispa* (the last of these is easily available only in Kampung Sat) were effective remedies. The leaves of *Solanum nigrum* and *Strobilanthes crispa* are used by the Orang Asli to treat non-communicable diseases (NCDs), such as diabetes and high blood pressure. In Malaysia, commercially, both *Sauropus androgynus* and *Strobilanthes crispa* are manufactured into pharmaceutical products such as pills and powders with the latter being used as an ingredient of drinks. They are accessible to the general public. According to key informants, most of these plants were prepared, cooked and used to treat the same type of ailments within all three settlements. Among the three villages, informants in Telimau could only identify six species, while informants over at Bukit Terang could recognize seven wild edible plants (the missing two were the naturalized species, *Erechtites valerianifolius* and *Strobilanthes crispa*). The villagers interviewed at Kampung Sat were familiar with all nine of the wild edible plants.

It is worth noting, that there were slight differences in the names used for each species in each village, except for *Manihot esculenta,* a cultivated and naturalized introduced species as shown in Figure 3. Based on this study, it was clear that these wild edibles still play a fundamental role in ensuring food security in these communities as the informants have mentioned that when they do not have enough money to buy domesticated crops, they will start gathering more from the jungle. Two of the nine wild edibles were ferns belonging to the Athyriaceae and Dryopteridaceae. All nine plants in the study belonged to different families (see Table 2). Many of these plants have been used for many generations. Although domestication efforts have been reported, they have not been successful for some of these wild edibles such as *Pleocnemia irregularis* (**sendap**) and *Diplazium esculentum* (**sayang**). This is because the (**sayang**) can only grow close to the river banks whereas **sendap** can only grow on stony humus rich soils. Meantime, *Solanum nigrum, Sauropus androgynous*, and *Manihot esculenta* are cultivated, particularly in Telimau since that village is relatively far from the jungle. This is not the case with Bukit Terang and Kampung Sat as these settlements are closer to jungle terrain. *Erechtites valerianifolius* and *Strobilanthes crispa* were only found in Kampung Sat, whereas *Gomphandra quadrifida* and *Pleocnemia irregularis* were not found in Telimau, but only in Bukit Terang and Kampung Sat. This is because Telimau is located in a mountainous area (~933 m above sea level) which limits the range of species that can survive there.

3.1. Trends according to gender and age of informants

The medicinal properties reported for the wild edible plants and the frequency of citation in all three villages are summarized in Table 3. Twenty-four citations were recorded for *Sauropus androgynus, Manihot esculenta, Diplazium esculentum,* and *Dendrocalamus asper* as they are frequency consumed and used by the Semai community. Some variability in the frequency of citation and knowledge associated with each species of WEP is seen, even though the snowball sampling technique was employed. In the case of *Strobilanthes crispa*, it was only the females in Kampung Sat who could identify its potential medicinal value as a diuretic agent as well as its ability to strengthen the immune system. Although all 24 informants managed to identify *Dendrocalamus*

TABLE 2 Wild edible plants identified at Pos Sungai Telimau (T), Bukit Terang (BT), and Kampung Sat (KS) settlements.

Local name	Scientific name	Vernacular names	Family name	Location (village)	Native or naturalized
Sayur manis (T) Pucuk manis (BT, KS).	*Sauropus androgynus* (L.) Merr.	**Malay** Asin-asin Cekur manis Chekop Sayur manis **Chinese** Mani cai **English** Sweet leaf bush	Phyllanthaceae	T, BT, KS	Native
Pucuk ubi	*Manihot esculenta* Crantz	**Malay** Ubi gajah Ubi kayu **English** Cassava Manioc Tapioca	Euphorbiaceae	T, BT, KS	Naturalized
Saya (T) Sayang (BT, KS)	*Diplazium esculentum* (Retz.) Sw.	**Malay** Paku anjing Paku benar Paku besar Paku tanjung **English** Vegetable fern	Athyriaceae	T, BT, KS	Native
Rebung (T, BT) Rabo (KS)	*Dendrocalamus asper* (Schult.) Backer	**Malay** Buluh betung Bambu petung **English** Giant bamboo	*Poaceae*	T, BT, KS	Naturalized
Meranti (T, BT) Kera (KS)	*Solanum nigrum* L.	**Malay** Terung meranti Terung para cicit Terung perat **English** Black nightshade Garden huckleberry	Solanaceae	T, BT, KS	Native
Pama (BT) Bern-go (KS)	*Gomphandra quadrifida* (Blume) Sleumer	**Malay** Lambas Kayu kestari hutan Lempedu tanah jantan	Stemonuraceae	BT, KS	Native
Sendap (BT) Ber-negy (KS)	*Pleocnemia irregularis* (C.Presl) Holttum	**Malay** Paku siar	Dryopteridaceae	BT, KS	Native
Snegoh (KS)	*Strobilanthes crispa* Blume	**Malay** Pecah beling Jin batu Bayam karang **Chinese** Hei mian jiang Hun (black face general) **English** Yellow strobilanthus	Acanthaceae	KS	Naturalized
Ber-pa (KS)	*Erechtites valerianifolius* (Link ex Spreng) DC.	**Malay** Pokok Sintrong **English** Tropical Burnweed	Asteraceae	3	Naturalized

asper, only informant 23, an elder female, was aware of its medicinal role in increasing one's appetite. Similarly, based on the results, it is clear that informants from Kampung Sat were more knowledgeable about the nine species and their various medicinal properties. From this we can postulate that indigenous knowledge of WEPs differs between and within settlements. The heterogeneity of knowledge within settlements is likely a result of the erosion of knowledge while differences between settlements are likely a product of the local environment and distance from Malay cities. Based on the results it seems that older individuals, especially older women in Bukit Terang and Kampung Sat were more knowledgeable in terms of recognizing and describing the medicinal properties of each plant than younger villagers.

TABLE 3 Frequency of citation by informants, and medicinal uses.

Species name	Frequency of citation	Reported medicinal properties (identification number of informants within parentheses)
Sauropus androgynus (L.) Merr.	24	Increases lactation in pregnant women (2, 4, 7, 10, 11, 12, 13, 17, 18, 19, 21–24) fever (17, 18, 21, 24), cough (11, 12, 17, 18, 19, 22, 24)
Manihot esculenta Crantz	24	Reduces tiredness (1, 6, 11, 22) and headache (22, 23) and induces labor (10, 11, 12, 22, 23, 24)
Diplazium esculentum (Retz.) Sw.	24	Skin infection (17, 18, 21, 22, 23), fever (11, 12, 13, 21, 22, 23) headache (1, 7, 11), diarrhea (11, 12), recovery after childbirth (11, 12,13, 22), and respiratory problems (23)
Dendrocalamus asper (Schult.) Backer	24	Increases appetite (23)
Solanum nigrum L	20	High blood pressure (1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 16, 18, 22)
Gomphandra quadrifida (Blume) Sleumer	10	Recovery after childbirth (19, 10, 11, 12, 19, 22, 23)
Pleocnemia irregularis (C. Presl) Holttum	12	Diarrhea (10, 11, 12, 13,14, 18, 19, 21, 22, 23) skin infection (22, 23, 24)
Strobilanthes crispa Blume	8	Diabetes (18, 19, 20, 21, 22,23), diuretic agent (22, 23), improves immune system (22, 23), treating wounds (17,18,19, 20, 21, 22, 23, 24)
Erechtites valerianifolius (Link ex Spring) DC.	6	Skin problems (17, 18, 22, 23), fever (22, 24), and tonsillitis (22, 23, 24)

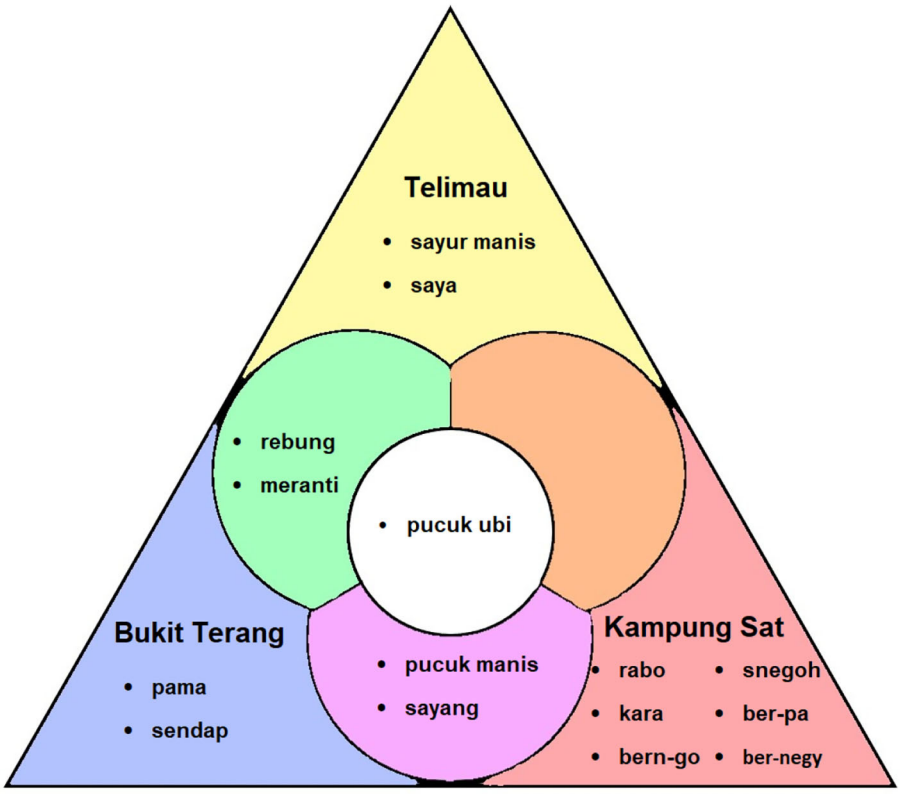

FIGURE 3
Common usage of name between villages.

4. Discussion

4.1. Difference in naming system

As the indigenous knowledge possessed by the Orang Asli is not documented, the names of wild edible plants may differ among villages. The local traditional names and classification system used by the Orang Asli are slowly being overwritten with the national (Malay) language and are being forgotten as a result of the National Government's cultural assimilation policy (Nicholas, 2000). This has resulted in these wild edible plants being identified based on their local Malay names rather than the local names identified by the Orang Asli. The name for *Sauropus androgynous*, "**sayur manis**," is the same in the local vocabulary as it is in the Malay vernacular. Other names correspond partially between the local and Malay vernacular terms, namely "**pucuk ubi**" (local) corresponds to "ubi gajah" and "ubi kayu" in vernacular Malay. This may be a result of Orang Asli social interactions with the Malay populace

from as early as the British occupancy to current times, and indicates the influence of the national language of Malaysia in their everyday lives. This point has also been highlighted by Turner et al. (2013), namely that semantic shift may occur as a result from cultural change. Additionally, semantic changes also happen when communities move to different vicinities, where they may lose access to particular vegetation communities. In the case of the Orang Asli, the resettlement programmes that were launched may have played an important role in this. Note also that interviews were carried out in Malay, so there may be some bias toward recognition of the Malay-like terms for particular plants.

Before the resettlement programmes began in the 1950s, the Orang Asli rarely communicated with other communities, except for those living nearby. In a study of the Orang Asli, Ong et al. (2011) observed that most Orang Asli communities considered themselves to be distinct from others, hence the different classification systems found in different Orang Asli ethnic groups. Nicholas (2003) reported a similar pattern in his study of the Orang Asli. Khasbagan (2008) investigated classification systems used by Mongolians in the Ejina desert area, and found that two or more local plant names could correspond to one scientific name and vice versa. In the present study, dual local names were seen for *Dendrocalmus asper* (**rebung** and **rabo**), *Gomphandra quadrifida* (**pama** and **bern-go**), *Solanum nigrum* L. (**meranti** and **kera**), *Diplazium esculentum* (Retz.) Sw, (**saya** and **sayang**), and *Pleocnemia irregularis* (**sendap** and bern-egy) in terms of traditional synonyms among the Orang Asli. We may deduce that there is a clear link between biodiversity and culture because these wild edibles play an important role in the Orang Asli culture in terms of productive, consumptive, ethical, aesthetic, social, and economic value. The relationship that humans have with plants is ancient and profound, so they can have a heavy influence on people's lives and affect the human conditions (Balick and Cox, 1996).

Of the nine wild edible plants, three are naturalized and were introduced by colonial powers; these are: *Manihot esculenta, Dendrocalamus asper,* and *Strobilanthes crispa.* Though *Manihot esculenta* was brought from Brazil into South East Asia, which then led to its naturalization process, the current supply of *Manihot esculenta* has been declining in recent years (FAOSTAT, 2017).

Article 8 in the Convention of Biological Diversity (1992) states that:

Subject to its national legislation, respect, preserve and maintain knowledge, innovations, and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations, and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations, and practices.

Consequently, ethnobotanists such as Berlin (1992) have made many inquiries into possible connections between traditional nomenclature and scientific names for species, with particular reference to conservation of biodiversity.

4.2. Domestication and conservation efforts

All the wild edible plants documented in this study are found growing in the jungle or near the river. However, with the clearing of the jungle to open up new farm lands, knowledge relating to the natural ecosystem and associated wild edible plants is declining as the skill set and knowledge for identifying WEPs is no longer practical or advantageous. The informants have highlighted that many of these wild edible plants are slowly becoming extinct due to deforestation, although domestication processes have been under way. The reason that some species have not been readily domesticated is because specific conditions are required such as greater elevation, or higher rainfall, as well as more fertile soil. The wild edible plants that play a more crucial role in the lives of the Semai are usually planted in their home gardens. Among the Semai in Telimau, this is the case for *Solanum nigrum* (**meranti**), *Sauropus androgynus* (**sayur manis**), and *Manihot esculenta* (**pucuk ubi**). These plants play an essential role in ensuring food security especially during seasons of drought, in addition to preserving the environment from threats of urbanization and deforestation. According to informant four, **meranti** (*Solanum nigrum*) was first harvested from the jungle and subsequently planted in their home gardens under controllable conditions, which then allowed the plant to become a domesticated variety. This has been confirmed by Heywood (1999) who mentioned that "domestication grew out of food gathering, which almost imperceptibly led to cultivation." As a result these plants are at different stages of domestication. Careful experimentation is conducted by the Semai to determine which wild edible plant is suitable for domestication.

4.3. Patterns according to gender and age of informants

Sauropus androgynus, Manihot esculenta, Diplazium esculentum, and *Dendrocalamus asper* were cited by all 24 informants as they are very common and frequently used by the Orang Asli. Despite the fact that the snowball sampling approach was used to help classify plants and evaluate the information possessed by Semai from various settlements, there were still variations. As can be seen from the results, in all three villages the older women were more experienced in recognizing, naming, and describing the medicinal properties of WEPs than the older males and younger generation. *Erechtites valerianiaeolia* (Link ex Spring) DC, was only found in Kampung Sat, so obviously only informants from Kampung Sat knew about its medicinal properties. In this case, it was only the females (informants 22 and 23) who were knowledgeable about its function as a diuretic and immune system strengthener. Another important thing to note here is that the Semai find it important to conserve these wild edibles as they have tried to domesticate these plants in all three villages. Also, taking care not to over-harvest these plants is another method the Semai highlighted, to assure continuous growth as they are acutely aware of the many losses of different flora and fauna in the rainforest.

Based on the results obtained, it can be said that the knowledge held among the Semai is heterogenous, both inter- and intra-settlement. This can be attributed to the locations of the settlements and the demographics of the Semai. With the former, the Semai in the more remote Kampung Sat settlement were able to recognize more WEPs of medicinal value, as their surroundings are relatively untouched and they are farther from the larger Malay cities. A study conducted by Hawkes (1996) among the Hazda and Kung hunter-gatherer communities from Tanzania and Bostwana reported that the activities they engaged in are based on gender and interests. The men

prefer hunting to boast about their dominance, conversely the women were in charge of gathering plants and jungle products as well as ensuring the wellbeing of their children. In addition, when a cash-dependent economy starts to kick in, many of the men will go into the jungle for days at a time, leaving the entire responsibility for the family's health to the women.

Similarly, a research study conducted among the Dayak women in Borneo (Gollin, 1997), found that the women were better-informed than men regarding the use of WEPs, and their medicinal properties. In light of the gender-age gap highlighted from the results, it can be inferred that the older women from all three settlements currently serve as repositories of traditional ethnomedical knowledge. Among the Orang Asli, the women were in charge of gathering wild plants as well as ensuring the health care of the family. After sedentism (living in groups in a single place for long periods) was introduced, the Orang Asli women were relegated from many decision-making activities (Lim and Chee, 1998). Therefore, providing a platform for the Orang Asli women to share their traditional knowledge and practices that have been passed along for many generations would help empower them to play a more active role in the community, indirectly leading to revitalization of the Semai culture which will then pave way for the integration process of the knowledge stream.

Voeks (2007) highlighted that tropical swidden ("shifting cultivation") includes a plethora of crop species and varieties, thus paving the way for many species to enter into pharmacopeias. It is also interesting to note that the naturalized *Strobilanthes crispa* plays an important role in the commercial pharmaceutical industry in Malaysia. This comes as no surprise as pharmacopeias are ever-changing and traditional healers are expected to investigate different plant species that become available in their local area (Palmer, 2004). Further investigation could be done by pharmacologists to assess the medicinal properties as well as the possibility of producing novel drugs from these wild edibles, although efforts should be made to protect the traditional rights of the Orang Asli.

4.4. Use of wild edible plants as medicines

Based on the results of this study, contingent upon the location of the settlements, Telimau and Bukit Terang, the Semai's use these wild edible plants as alternative medicines continues to some degree, although there is a gap in knowledge between the older and younger generations. The declining use of traditional herbal remedies may be due to the accessibility and availability of modern "western" medicine; it also showcases a form of deculturation amongst the Orang Asli.

The use of wild edible plants as medicine among the Semai in Kampung Sat is the primary source of health care as members of this community not only detest visiting physicians, but are also conscious of the significance of tradition. This may reflect the fact that Kampung Sat is more remote than the other two villages.

> *"We still practice what our forefather has taught us, and I will continue to teach my children about these medicinal plants."*
> Informant 17, male, 41 years old.

In contrast to young people in the other two settlements, the younger Semai in Kampung Sat are still actively practicing traditional ethnomedicine as they are proud of their heritage and aim to preserve this knowledge stream. Ceuterick et al. (2008) have pointed out that the use of traditional medicines plays an essential part as an ethnic marker. Therefore, particularly in the more Northern settlements of Telimau and Bukit Terang, the erosion of this body of knowledge could further undermine the Semai's sense of identity.

4.5. Medicinal value

A literature review was conducted to assess the medicinal uses of these plants by the Orang Asli. Berlin (1992) mentioned in his work that *Sauropus androgynous* (**pucuk manis**) is associated with weight loss and helps enhance vision among those who consume it (Berlin, 1992). The high antioxidant content of the leaves is due to the elevated vitamin C and E content (Yu et al., 2007). It is also known as a multigreen or multivitamin source due to the high amounts of vitamin, protein content and affordability (Nahak and Sahu, 2010). Numerous researchers have reported on its anti-diabetic properties, anti-dyslipidemic, anti-anemic, anti-inflammatory, and anti-obesity effects activities (Han et al., 2001; Singh et al., 2011; Kumar and George, 2015; Suparmi et al., 2016). Among other advantages of consuming this plant include increasing milk production among mothers, post-pregnancy. As a result, Orang Asli women are encouraged to consume more of this plant after giving birth (Warditiani et al., 2016).

The potential of cassava leaves has not been fully exploited due to the stigma associated with it being seen as a "poor man's crop." The leaves are rich in minerals such as calcium, magnesium, iron, manganese, zinc, and vitamin A and C (Andarwulan et al., 2012). Owing to its inexpensive production cost, cassava can be considered an alternative food source for consumers in underdeveloped and developing countries (Ravindran, 1992). However, if a large amount of cassava leaf tissue is consumed, it can halt the digestion process and subsequently stop the absorption of nutrients due to their toxic nature as well as the anti-nutritional compounds present (Ravindran and Rajaguru, 1988). It is important to note that raw cassava plants contain considerable amounts of cyanogenic glycosides, which generate the poison, cyanide, so they are dangerous as the only fodder for goats, etc. Provided the plant is cooked, or dried in the sun, however, it is very nutritious.

Erechtites valerianifolius is a good source of micronutrients such as β-carotene, vitamin C, potassium, zinc, and iron and carbohydrate (Wobeto et al., 2006). In a recent study conducted in Brazil, it was reported that it would make a good source of nourishment based on its availability and its potential to fulfill the daily recommended nutrient intake, thus possibly decreasing nutritional deficiencies among the general populace (Barreira et al., 2019). However, this may depend on the environmental conditions under which the plant is grown, as this will affect the nutrient content of the plants, as this plant has a predilection for wetland ecosystems (Schwirkowski, 2013).

It has been reported that *Diplazium esculentum* is rich in antioxidants such as flavonoids, steroids, polyphenols, alkaloids, terpenoids, tannins, and saponins (Wahab et al., 2015; Halimatussakdiah and Wahyuningshi, 2018). It is also worth noting that compared to many commercial fruits available in the market, the mineral content of this species is very high, according to Badola (2010). There is a slightly bitter taste associated with this fern, and

caution is advice when consuming the fronds. Although *Diplazium esculentum*, is mainly collected from the wild, efforts have been under way to domesticate this fern (de Winter and Amoroso, 2003). It also has been reported that the leaves can be used as a tonic after childbirth (Bidin, 1985).

Bamboo is a good source for vitamins such as niacin, vitamin A, B6, C, E, and thiamine as well as minerals like potassium, calcium, manganese, zinc, chromium coper, and iron (Nirmala et al., 2007). Multiple value-added products have been developed ranging from nuggets, pickle, crackers, wine, and soft drinks which can be attributed to its distinctive taste and crunchy texture (Pandey et al., 2012). Among the many medicinal properties linked with bamboo are that it is anti-inflammatory, antitumor and anti-diabetic; it reduces blood pressure and cholesterol while boosting appetite levels (Katarzyna et al., 2019). The mechanism by which blood pressure is reduced is related to the high fiber and phytosterol content of bamboo; the bamboo fiber appears to reduce blood lipids in terms of the Atherogenic Index (which includes triglycerides and high-density lipoprotein cholesterol) which has the ability to thin the arteries and maintain blood pressure (Park and Jhon, 2009; Nongdam and Tikendra, 2014). The antioxidant, phytosterol resembles cholesterol in terms of its structure; it has been shown to moderate the absorption of cholesterol in the intestinal mucosa (Nongdam and Tikendra, 2014).

Zakaria et al. (2009) pointed out that the leaves and fruits of *Solanum nigrum* have been used traditionally to treat diabetes and high blood pressure. Recent medical studies have shown its efficacy in decreasing blood glucose and lipid levels in the body and is also effective in reducing cardiovascular problem in diabetic patients (Sohrabipour et al., 2013). Similarly (Schilling et al., 1992), have reported that *Solanum* has been used effectively to treat hypertension, supporting the traditional use of this species by the Orang Asli. The Temuans, a "proto-Malay" ethnic group living mostly in the south-western states of the Malay peninsula, have long used *Pleocnemia irregularis* to treat diarrhea, skin disease and weak muscles (Ong et al., 2011). The Orang Asli are not too concerned about the disappearance of this fern as it grows near the settlement and is still easily available.

The leaves of *Strobilanthes crispa* are sold commercially as a "health enhancer" and have long been cultivated in Malaysia for their use in the pharmaceutical industry. The plant's health benefits have been long established in the sphere of traditional medication and it is used to treat diabetes, high blood pressure and as a diuretic agent (Yap et al., 2017). Leaves of *Strobilanthes crispus* are boiled down to make a tea; they can also be infused in water as they contain a high level of minerals, polyphenols and vitamins (Ismail et al., 2000). According to recent studies, the compounds present in the leaves may include anti-carcinogens, so the plant has the potential to be used as an effective chemotherapeutic agent (Yaacob et al., 2010).

These reports from the published research literature confirm and support the perspectives of the Orang Asli in relation to traditional medicines, as captured by our interviews. The biochemical and antioxidant compounds present in these wild edible plants alongside their nutritional value surpass many domesticated crops. Though many of these species have been documented, they remain relatively unknown among the general populace. The mechanisms whereby these compounds interact to treat diseases need further study; this can be used as basis for discovering novel compounds as well as gain a deeper understanding of the mechanisms behind drug action (Ong and Azliza, 2015). In order to recognize the processing of any toxic compounds found in these plants, the preparation methods, supplementary ingredients, and frequency of consumption should also be documented. This is because traditional medicines tend to possess a higher number of active ingredients and potentially harmful components. Similarly, Lambin et al. (2018) concluded that the traditional ethnomedicinal knowledge held by the Orang Asli could help facilitate and expedite scientific studies on novel chemical compounds, ultimately leading to the development of viable drugs for current medicinal treatment.

For this research, there are several limitations that the researcher faced. First, the limited villages utilized in this research prove to be a stumbling block, as it might not accurately represent the other villagers located in different states. Also, the study was only based on the Semai and not the other Orang Asli ethnic groups. Additionally, the researcher is working full-time, and the limitation on time proved to be a barrier. Hence only nine wild edible plants were identified during this time. Future studies on wild plants used by the Orang Asli should include a broader range of villages that encompass the Negrito and Proto-Malay ethnic groups to allow for a fuller comparative study and statistical analysis to reflect results accurately.

5. Conclusion

This research identified nine wild edible plants that are commonly used by the Orang Asli, and their names, and medicinal uses in three different settlements. It is expected that the findings from this research could also potentially raise awareness among urban populations concerning some of the benefits associated with the protection of indigenous people, and conservation and consumption of these wild edibles, thus contributing to the present body of knowledge. These wild edibles are multifaceted in nature and more has to be done particularly in terms of the conservation of the knowledge associated with these plants. Other initiatives should include protection of the natural habitats where they are found, and preservation of the plants' gene pools. Community knowledge about these plants clearly plays a significant role in maintaining the distinct cultural identity of the Orang Asli and reinforcing the relationship they have with their environment.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

RT was responsible for design and writing and has read and approved the final manuscript.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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