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Any alternatives to rice? Ethnobotanical insights into the dietary use of edible plants by the Higaonon tribe in Bukidnon Province, the Philippines

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ABSTRACT

Though considered an agricultural country, the Philippines is the world's largest importer of rice. The persistent problem of insufficient rice supply, however, has been exacerbated by economic crises and natural calamities. Yet, for the Higaonon tribe in Bukidnon Province, the Philippines, the rich agrobiodiversity and wild edible plants are vital for food security and resilience since the mountainous terrain in this province presents a challenge for rice cultivation. To gain insight from the indigenous edible plant knowledge of the Higaonon tribe, we conducted an ethnobotanical research to document the diversity, utilization, and biocultural refugia of both cultivated and wild edible plants. A total of 76 edible plant species belonging to 62 genera and 36 botanical families were documented. The most represented botanical families included the Fabaceae, Solanaceae, and Zingiberaceae. In terms of dietary usage, 3 species were categorized as cereals; 8 species were white roots, tubers, and plantains; 3 species were vitamin A-rich vegetables and tubers; 16 species were green leafy vegetables; 12 species were categorized as other vegetables; 2 species were vitamin A-rich fruits; 27 species were classified as other fruits; 7 species were legumes, nuts, and seeds; and 8 species were used as spices, condiments, and beverages. Using the statistical software R with ethnobotanyR package, we further calculated the ethnobotanical indices (use-report (UR), use-value (UV), number of use (NU), and fidelity level (FL)) from 1254 URs in all 9 food use-categories. The species with the highest UV and UR were from a variety of nutrient-rich edible plants such as *Ipomoea batatas* (L.) Lam., *Musa* species, *Colocasia esculenta* (L.) Schott, *Zea mays* L., and *Manihot esculenta* Crantz. The extensive utilization of root and tuber crops along with corn and plantain that contain a higher amount of energy and protein, carbohydrates, minerals, and vitamins were shown to be an important nutrient-rich alternatives to rice. Whilst males appeared to be more knowledgeable of edible plant species collected from the forests and communal areas, there were no significant differences between males and females in terms of knowledge of edible plants collected from homegardens, riverbanks, and farms. The various food collection sites of the Higaonon tribe may be considered as food biocultural refugia given their socio-ecological function in food security, biodiversity conservation, and preservation of indigenous knowledge.

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1. Introduction

About 690 million people (8.90% of the world population) worldwide suffer from hunger, with an increase of approximately 10 million people every year and a total increase of nearly 60 million people in the last 5 years (FAO et al., 2020). As such, the challenge of achieving food security has been listed as one of the 17 Sustainable Development Goals (SDGs) aimed to be accomplished by all the United Nations (UN) members in 2030 (UN, 2015). Achieving food security, eradicating hunger, improving human nutrition, and promoting sustainable agriculture are the goals of the UN SDG 2 (Hunter et al., 2019). Furthermore, the UN highlighted the potential benefits of indigenous knowledge in attaining food security through sustainable and proper utilization of biocultural resources.

Failed agriculture, hunger, and undernutrition were problems faced by many developing countries in the 1972–1973 and 2007–2008 world food crises triggered by the global scarcity and unaffordability of rice (Dawe, 2010). A number of countries were impacted together with the Philippines, which is part of the current global food system that primarily depends on 3 staples: wheat, maize, and rice (Hunter et al., 2019). The Philippine government addressed these food crises by importing more rice making the Philippines become the world's largest rice importer (Dawe et al., 2006; Dawe, 2010). By 2019, the Philippines still held this record with an estimated total import of 2.90×10^6 t of rice (dela Cruz, 2020a, b). However, the recent natural calamities have shocked the global economy and disrupted the international supply chains, particularly on agricultural products (Lin and Zhang, 2020). Cambodia executed a temporary ban on rice export while Vietnam, the world's third-largest rice exporter, also momentarily deferred new contracts for rice exportation, with the Philippines seeking an additional 0.30×10^6 t rice which were on top of its 1.30×10^6 t rice import to ensure sufficient domestic supply (dela Cruz, 2020a, b). About 15 million families consume rice at approximately 463.00 kg per family per year or 8.90 kg per family per week in the Philippines (Philippine Statistics Authority, 2010). According to dela Cruz (2021), the Philippine government imported approximately at least 1.69×10^6 t of rice to meet the needs of the Filipinos in 2021.

This socio-economic burden, however, may be unnecessary considering that the undiversified rice-centered diet of Filipinos has serious health consequences (Angeles-Agdeppa et al., 2019, 2020). The typical Filipino diet, i.e., rice with meat or fish and sugar-sweetened beverage, is extremely deficient and lacking of essential macro- and micro-nutrients (Angeles-Agdeppa et al., 2019, 2020), so finding an alternative food source is not the solitary problem as the Food and Agriculture Organization (FAO) changed the definition of food security to "food and nutrition security", mirroring the increasing apprehension on micronutrient deficiencies (Blesh et al., 2019). According to the FAO, food and nutrition security can be met if everyone has physical, economic, and social access to enough food with adequate quantity and quality, i.e., to suit their food preferences and nutritional requirements in terms of food diversity, nutrient quality, and safety aspects (FAO et al., 2020).

Unfortunately, local varieties and breeds of domesticated plants and animals are disappearing worldwide along with the associated indigenous and local knowledge due to a shift towards intensification of agriculture with a small number of improved crop species and varieties (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2018). The decline in traditional agrobiodiversity and genetic diversity poses a serious risk to global food security by undermining the resilience of many local communities (IPBES, 2018). In the case of the Oraon tribe in India, for example, the revitalization of indigenous food consumption appeared to be potentially valuable in improving the dietary diversity and nutrient intake amongst the underprivileged tribal community (Ghosh-Jerath et al., 2018). Thus, the documentation and *in situ* conservation of indigenous edible plant resources are of particular significance in addressing the present concern on food and nutritional security.

Apart from rice, several species of edible plants have been used by various local and ethnic cultures, in particular, by indigenous peoples. Many ethnic groups and indigenous communities have extensive knowledge of edible plants, many of which are neglected and underutilized species (Kuhnlein, 2009; Padulosi et al., 2013; Del-Castillo et al., 2019; Hunter et al., 2019; Ulian et al., 2020). The traditional food system of the indigenous peoples plays an important role in local food security by making them independent from the market system. The food system of indigenous peoples can be defined as foods that are free and locally accessible to the indigenous peoples. Moreover, indigenous peoples possess indigenous knowledge about edible plants in their local natural environment, either through farming or wild harvesting (Kuhnlein, 2009). This is in contrast to "market foods" that can be purchased from various commercial producers (i.e., cooking oil, canned foods, sugar, instant noodles, etc.), although in some circumstances, indigenous peoples may purchase some of their foods (i.e., coffee beans, poultry products, wildmeat, rice, and wild vegetables) from others who own land and/or have time to collect or harvest in their community (Kuhnlein, 2009).

However, based on the IPBES, the consumption of traditional foods in the Asia-Pacific region is decreasing due to urbanization, rapid economic development coupled with growth in international trade, rural out-migration, and changes in lifestyles and dietary habits (IPBES, 2018).

As such, the rich indigenous knowledge about the use of neglected and underutilized edible plant species offers a largely unexploited resource to support food security, combat malnutrition, and achieve sustainable agriculture (Borelli et al., 2020; Ghosh-Jerath et al., 2020; Ulian et al., 2020), i.e., the key goals of SDG 2. An ethnobotanical approach is particularly promising in a biodiversity-rich yet food insecure country like the Philippines. With approximately 110 ethnic groups of indigenous peoples and over 1.0×10^4 plant species, the Philippines may be one of the most important biocultural refugia for ethnobotanical studies in Asia (Buenavista, 2021). However, indigenous peoples' land is rapidly diminishing as agricultural plantations (i.e., banana and pineapple plantations) encroach and expand in the Philippine uplands (Huesca, 2016). In the case of the Bukidnon Province in Mindanao, a considerable land area has been transformed into the country's largest production site for pineapple (59.73 t/hm^2) and other cash crops such as rubber and tobacco for export (Philippine Statistics Authority, 2018). Although agricultural productivity increased in Mindanao due to large-scale agricultural investments, these investments have fallen short to curb the persistent poverty or improve the well-being of the people in the upland communities (Huesca, 2016). The Higaonon tribe in the Bukidnon uplands is among the most affected groups of indigenous peoples in Mindanao. The ancestral domains managed by the Higaonon tribe cover the key biodiversity areas of conservation value and the biocultural refugia for important food sources for the indigenous peoples (Abeto et al., 2004; Bukidnon-Higaonon Community of Malabalay City et al., 2019).

The availability of useful ethnobotanical information is particularly valuable considering that many households were often affected by the disruption of food supply and loss of income. Moreover, the FAO's report showed an increased gender gap in accessing food wherein the prevalence of food insecurity is higher among females than males, regardless of the level of severity (FAO et al., 2020). Furthermore, the same report strongly emphasized the need for transforming the future food systems to significantly accelerate progress towards the realization of the SDGs, especially on improving the state of global food security and gender equality (FAO et al., 2020). Indigenous peoples were specifically involved in the two SDGs and targets, i.e., SDG 2 which aims to achieve food security, eradicate hunger, improve human nutrition, and promote sustainable agriculture, and SDG 4 Section 4.5 on eliminating gender disparities (Buenavista et al., 2018).

In this study, we aimed to gain insight from the indigenous knowledge system and food ethnobotany of the Higaonon tribe in Bukidnon Province, the Philippines. Since the mountainous terrain in Bukidnon Province presents a challenge for rice cultivation, we hypothesized that the Higaonon tribe has adopted a more diversified diet consisting of various staple crops other than rice. Like any other indigenous communities, the indigenous knowledge of the Higaonon tribe is associated with various understudied food biocultural refugia or biodiverse sites of cultural and economic value which are vital for food production and conservation of indigenous food heritage. As such, we conducted an ethnobotanical study to explore the dietary usage of edible plants from the different biocultural refugia of the Higaonon tribe; specifically, this study aimed to answer the following questions:

(1) Which edible plant species constitute the Higaonon food system?
(2) What are the dietary uses of edible plants based on the FAO food use-categories?
(3) Is there a difference between males and females in the Higaonon household in terms of knowledge of edible plants (total number of recognized species in all sites and specific collection sites, i.e., homegardens, forests, etc.)?
(4) How adaptive is the Higaonon food system within the context of rice shortage and nutrient-poor diet in the Philippines?

2. Materials and methods

2.1. Study area

This study was conducted in the 5 rural villages of Barangay Dumalaguing, Municipality of Impasug-ong, Bukidnon Province, the Philippines. The 5 villages are: (1) Dumalaguing, located in 08°20′43″N and 125°03′22″E (677 m a.s.l.); (2) Bundaan, located in 08°21′19″N and 125°04′56″E (1093 m a.s.l.); (3) Kalipayan, located in 08°21′39″N and 125°01′58″E (1085 m a.s.l.); (4) Gabunan, located in 08°21′43″N and 125°02′38″E (1232 m a.s.l.); and (5) Bati-aw located in 08°19′36″N and 125°04′07″E (1188 m a.s.l.).

2.2. Ethnobotanical data collection

After obtaining the permissions from the Barangay officials of Dumalaguing and the Chieftain or Datu of the Higaonon tribe, interviews were conducted in the 5 villages. Based on accessibility, we selected the households in each village with a total of 100 respondents. The Higaonon respondents are of legal age ($\geq$18 years) and permanent village residents. With the assistance of a local translator, the researchers visited each household to secure the free and prior informed consent. The rationale and goal of the interview were explained in Bisaya and Binukid language. Any of the adult members of the family primarily responsible for the harvesting, gathering, and/or cooking of food, either the mother, father, or grandparent, were then invited to take part voluntarily in the interview. After obtaining the verbal and written consent, the structured interview was initiated by recording the personal and socio-economic profile of the respondents. We administered the interview in accordance with the customary practices of the Higaonon tribe. Generally, this was done within the respondent's house or by invitation into the village leaders' household, albeit some of the interviews were walking interviews whilst harvesting edible plants within the homegarden, community, or forest. The walking interview also proved to be helpful since the edible plants particularly those collected from the forest and communal areas can be directly identified and described by the respondents. It also aided the researchers in documenting the ethnobotanical utilization of edible plants as well as in providing preliminary field identification. The elicited ethnobotanical information was recorded in the datasheet, including the local name of the plants, edible parts of the plants, manner of food consumption, and place of the collection. After interview, we asked the respondents to verify the list for completeness and accuracy. A guided field survey was also conducted to locate the unidentified edible plants for documentation and taxonomic verification, in particular, the wild edible plants traditionally gathered from forests. This also included the plants that were occasionally consumed, such as those considered as famine food or poisonous plants that require further processing. This study considered both cultivated and wild edible plants utilized by the Higaonon tribe. We adopted the FAO (1999) definition for "wild" plant species which specifically refers to plants that grow concurrently in self-maintaining populations in a natural or semi-natural habitat without direct human action. It is in contrast with "cultivated" or "domesticated" plant species that require human management activity for their continued existence, such as selection or breeding (FAO, 1999). In this study, the edible plants included the plants those were gathered (not cultivated) and even those were grown in the homegardens or cultivated lands instead of forests (Termote et al., 2011). All the plants were taxonomically identified by the first author in consultation with other taxonomists at Central Mindanao University Herbarium, Bukidnon Province, the Philippines. The taxonomic treatment and botanical nomenclature used in this study were referred from the Kew's Plants of the World online database (http://powo.science.kew.org/) and Co's Digital Flora of the Philippines (https://www.philippineplants.org/).

3. Data analysis

The field data were organized in a Microsoft Excel spreadsheet for analysis. Using the checklist of all the collected edible plants, we calculated the frequencies and percentages of botanical families, genera, and species, as well as their life-forms, collection sites, and edible parts. We classified the edible plants following the FAO food use-categories: cereals; white roots, tubers, and plantains; vitamin A-rich vegetables and tubers; green leafy vegetables; other vegetables; vitamin A-rich fruits; other fruits; legumes, nuts, and seeds; spices, condiments, and beverages (Kennedy et al., 2010).

For quantitative ethnobotanical analysis, we used the statistical software R with ethnobotanyR package to calculate the following indices: use-report (UR), use-value (UV), number of uses (NU), and fidelity level (FL) (Whitney, 2021). The aforementioned indices were calculated using the formulas in Table 1.

We generated a Venn diagram to visualize and compare the species richness of edible plants in the 5 villages by using an online tool freely provided by Ghent University, Belgium (http://bioinformatics.psb.ugent.be/webtools/Venn/).

To determine the difference in the plant knowledge between males and females in the Higaonon household, we used a student *t*-test to compare the mean of the total number of edible plants reported by each gender group, and determined the level of significance at $P < 0.05$ level. We also utilized the analysis of variance (ANOVA) test to compare the knowledge of edible plants by gender group in different collection sites (i.e., homegardens, forests, and communal areas) in all 5 villages. The statistical analyses were done using the SPSS version 24.0 software package for Windows.

4. Results

4.1. Demography of respondents

Out of the 100 respondents interviewed from the 5 villages, nearly three quarters (73.00%) reached a primary level education, 16.00% had no formal education, 10.00% attended to secondary level education, and only 1.00% attended college or other tertiary level. Only kindergartens and primary schools existed in the villages, students from the furthest village (Bati-aw) had to walk for 2–3 h to secondary school. In most cases, children finished education after primary school to conduct farm work. Most of the respondents were farmers (79.00%), 3.00% of respondents worked for the local government, and 18.00% of respondents worked at home or engaged in other occupations. Some respondents were farm owners but they were also employed by the government, or local business owners of “sari-sari”, or grocer. About 52.00% of respondents earned less than 19.49 USD per month (19.49 USD = 1000 Php), 47.00% of respondents had a monthly income of 19.49–97.45 USD per month, and only 1.00% of respondents earned 116.94–194.90 USD per month (Table 2).

Village incomes were largely derived from selling abaca fibers or hemp, coffee beans, vegetables (i.e., tomatoes, chili peppers, sweet peas, etc.), peanuts, corn, handicrafts such as rattan bags and baskets, and sleeping mats crafted using sedge locally known as “tikug” (*Fimbristylis umbellaris* (Lam.) Vahl) and “sudsud” (*Cyperus iria* L.). However, the majority of the Higaonon households relied on a once-a-year harvest of coffee. The roads from farms to markets remained a major constraint for the Higaonon farmers since it was only traversable by motorcycle or on foot, and the road construction only started in 2019. Moreover, the village of Bati-aw had no electricity or water supply system to date. This situation placed an economic burden on the Higaonon farmers whose incomes were further curtailed by high-priced transportation (2.92 USD/delivery) and low buying prices for coffee beans (0.97 USD/kg) and other farm products delivered to the city.

4.2. Botanical diversity of edible plants

A total of 76 edible plant species (Fig. 1) belonging to 62 genera (Fig. 2) and 36 botanical families constituted the traditional food system of the Higaonon tribe. The botanical families yielding the highest number of edible plants were Fabaceae, Solanaceae (nightshades), and Zingiberaceae (gingers), with 6 species each. This was followed by Poaceae (grasses) and Cucurbitaceae (gourd), with 5 species for each, along with Rutaceae (citrus) and Malvaceae (mallows), with 4 species each. The list also included families of Araceae

Table 1
Formulas used for calculating the ethnobotanical indices in this study.

Ethnobotanical index	Formula/Explanation	Reference
Use-report (UR)	Total reported uses of each plant species in all the use-categories by all respondents.	Prance et al. (1987)
Use-value (UV)	UV=$(\sum U_i)/n$, where U_i is the number of uses (counted based on the *i*th FAO food use-category) mentioned by each respondent; and *n* equals the total number of respondents interviewed. The UV index determines the most widely used edible plant species (the highest UV) as well as the underutilized species (the lowest UV, approaching 0). The UV index, however, cannot determine whether the species is used singly or for multiple purposes.	Phillips and Gentry (1993)
Number of uses (NU)	The sum of all the use-categories for which a species is cited.	Prance et al. (1987)
Fidelity level (FL; %)	FL=$(i_p/i_u) \times 100\%$, expressed as the ratio of the total number of respondents who independently suggest the use of a species for a specific use-category (i_p) and the total number of respondents who mention the plants for any uses irrespective of the use-category (i_u).	Friedman et al. (1986)

Table 2
Personal and socio-economic information of the 100 respondents from the Higaonon tribe.

Statistic	Number of respondents (*n*)	Percentage (%)
Village		
Bati-aw	22	22.00
Gabunan	14	14.00
Bundaan	16	16.00
Kalipayan	24	24.00
Dumalaguing	24	24.00
Sex		
Male	26	26.00
Female	74	74.00
Education		
No formal education	16	16.00
Primary level	73	73.00
Secondary level	10	10.00
Tertiary level	1	1.00
Occupation		
Farmer	79	79.00
Government employee	3	3.00
Others	18	18.00
Estimated monthly income		
<19.49 USD per month	52	52.00
19.49–97.45 USD per month	47	47.00
116.94–194.90 USD per month	1	1.00

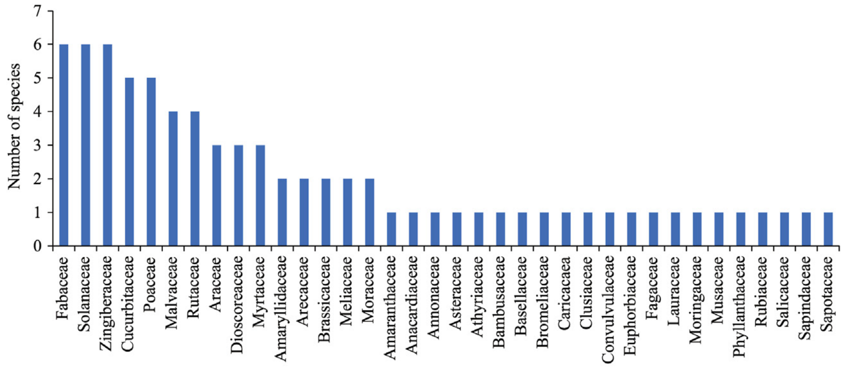

Fig. 1. Number of edible plant species per botanical family in the Higaonon tribe.

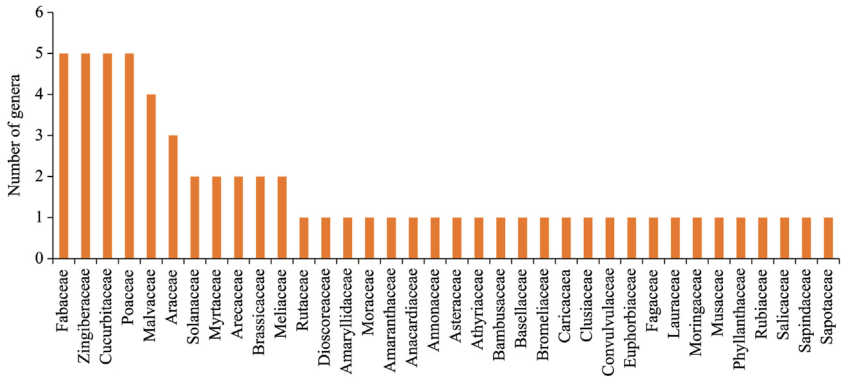

Fig. 2. Number of edible plant genera per botanical family in the Higaonon tribe.

(aroids), Dioscoreaceae (yams), and Myrtaceae (myrtle), with 3 species for each. Twenty-one plant families contained a single species, including Amaranthaceae, Anacardiaceae, Annonaceae, Asteraceae, Athyriaceae, Bambusaceae, Basellaceae, Bromeliaceae, Caricaceae, Clusiaceae, Convolvulaceae, Euphorbiaceae, Fagaceae, Lauraceae, Moringaceae, Musaceae, Phyllanthaceae, Rubiaceae, Salicaceae, Sapindaceae, and Sapotaceae.

4.3. Quantitative ethnobotanical analysis

A total of 1254 URs were reported from all the FAO food use-categories (Fig. 3). Out of 76 edible plant species, 3 species (3.94%) were classified cereals; 8 species (10.52%) were white roots, tubers, and plantains; 3 species (3.94%) were vitamin A-rich vegetables and tubers; 16 species (21.05%) were eaten as green leafy vegetables; 12 species (15.78%) were categorized as other vegetables; 2 species (2.63%) were vitamin A-rich fruits; 27 species (35.52%) were considered as other fruits; 7 species (9.21%) were legumes, nuts, and seeds; and 8 species (10.52%) were used as spices, condiments, and beverages. A few species had multiple usages. For example, for *Calamus* sp. (rattan), its pith in the stem can be cooked and eaten as a vegetable (belonging to the other vegetables category) aside from its edible fruits (belonging to the other fruits category); for *Coix lacryma-jobi* L. (Job's tears), its seeds are also an important rice substitute (belonging to the cereals category) and are fermented to produce the Higaonon tribe's rice wine locally known as "langkuga" (belonging to the spices, condiments, and beverages category); for *Capsicum annuum* L., its fruits can be used as seasoning spices (belonging to the spices, condiments, and beverages category) and vegetables (belonging to the vitamin A-rich vegetable category), and its leaves and shoots are also cooked as vegetables (belonging to the green leafy vegetable category). The checklist of edible plants in the Higaonon tribe including their local usage and ethnobotanical value is summarized in Table 3.

The edible plant species with the highest UR and UV (Table 3; Fig. 4) were *Ipomoea batatas* (L.) Lam. (UR = 150, UV = 1.50), *Musa* sp.

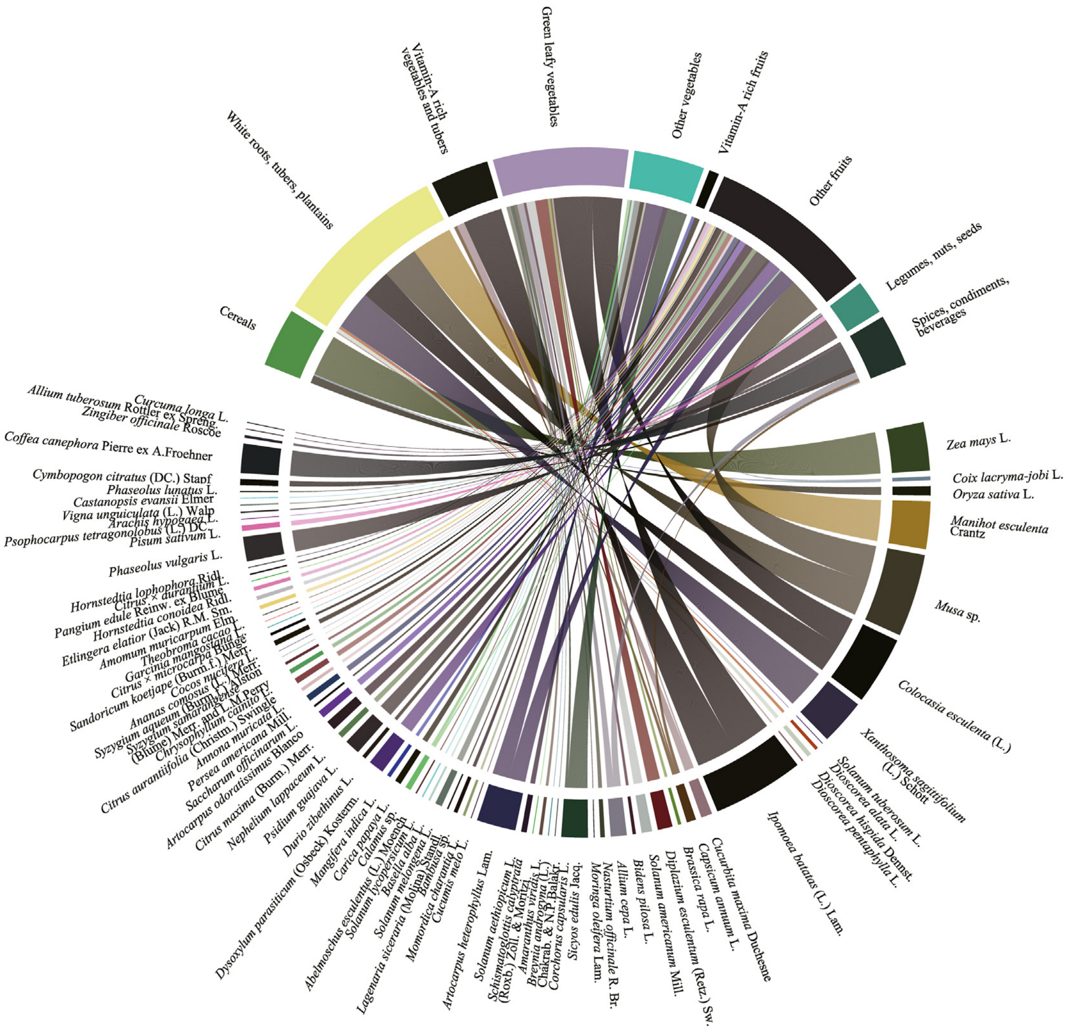

Fig. 3. Chord diagram showing the distribution of 1254 use-reports (URs) for the 76 edible plant species (shown in the bottom half part of the chord diagram) utilized by the Higaonon tribe in the 9 use-categories (shown in the top half part of the chord diagram). The 9 use-categories include (1) cereals; (2) white roots, tubers, and plantains; (3) vitamin A-rich vegetables; (4) green leafy vegetables; (5) other vegetables; (6) vitamin-A rich fruits; (7) other fruits; (8) legumes, nuts, and seeds; and (9) spices, condiments, and beverages.

Table 3
Checklist of the 76 edible plant species utilized by the Higaonon tribe.

Botanical family	Scientific name	Source	Life-form	Edible part	UR	UV	NU	FL
Amaranthaceae	*Amaranthus viridis* L.	W	Herb	Leaf and shoot	5	0.05	1	G: 100%
Amaryllidaceae	*Allium cepa* L.	C	Herb	Leaf	26	0.26	2	G: 100%; S: 100%
Amaryllidaceae	*Allium tuberosum* Rottler ex Spreng.	C	Herb	Leaf	1	0.01	1	S: 100%
Anacardiaceae	*Mangifera indica* L.	C	Tree	Fruit	6	0.06	1	OF: 100%
Annonaceae	*Annona muricata* L.	C	Tree	Fruit	5	0.05	1	OF: 100%
Araceae	*Xanthosoma sagittifolium* (L.) Schott	C/W	Herb	Corm	76	0.76	1	W: 100%
Araceae	*Colocasia esculenta* (L.) Schott	C/W	Herb	Corm and young leaf	111	1.11	2	W: 100%; G: 100%
Araceae	*Schismatoglottis calyptrata* (Roxb.) Zoll. & Moritzi	W	Herb	Young leaf	1	0.01	1	G: 100%
Arecaceae	*Cocos nucifera* L.	C	Tree	Fruit	8	0.08	1	OF: 100%
Arecaceae	*Calamus* sp.	W	Shrub	Fruit and pith	9	0.09	2	OV: 100%; OF: 50%
Asteraceae	*Bidens pilosa* L.	W	Herb	Young leaf and shoot	5	0.05	1	G: 100%
Athyriaceae	*Diplazium esculentum* (Retz.) Sw.	W	Herb	Leaf and shoot	24	0.24	1	G: 100%
Bambusaceae	*Bambusa* sp.	W	Shrub	Shoot	6	0.06	1	OV: 100%
Basellaceae	*Basella alba* L.	C	Herb	Leaf and shoot	3	0.03	1	OV: 100%
Brassicaceae	*Nasturtium officinale* R. Br.	W	Herb	Leaf	7	0.07	1	G: 100%
Brassicaceae	*Brassica rapa* L.	C	Herb	Leaf and shoot	5	0.05	1	G: 100%
Bromeliaceae	*Ananas comosus* (L.) Merr.	C	Herb	Leaf	1	0.01	1	OF: 100%
Caricacaea	*Carica papaya* L.	C	Herb	Fruit	10	0.10	1	VF: 100%
Clusiaceae	*Garcinia mangostana* L.	C	Tree	Fruit	1	0.01	1	OF: 100%
Convolvulaceae	*Ipomoea batatas* (L.) Lam.	C	Herb	Leaf, shoot, and tuber	150	1.50	2	VA: 100%; G: 100%
Cucurbitaceae	*Sicyos edulis* Jacq.	C	Herb	Leaf, shoot, and fruit	43	0.43	2	OV: 100%; G: 13.16%
Cucurbitaceae	*Cucurbita maxima* Duchesne	C	Herb	Shoot and fruit	18	0.18	1	VA: 100%; G: 20%
Cucurbitaceae	*Momordica charantia* L.	C	Herb	Shoot and fruit	4	0.04	1	OV: 100%
Cucurbitaceae	*Lagenaria siceraria* (Molina) Standl.	C	Herb	Fruit	2	0.02	1	OV: 100%
Cucurbitaceae	*Cucumis melo* L.	C	Herb	Fruit	1	0.01	1	OV: 100%
Dioscoreaceae	*Dioscorea hispida* Dennst.	W	Herb	Tuber	7	0.07	1	W: 100%
Dioscoreaceae	*Dioscorea alata* L.	C	Herb	Tuber	5	0.05	1	W: 100%
Dioscoreaceae	*Dioscorea pentaphylla* L.	W	Herb	Tuber	2	0.02	1	W: 100%
Euphorbiaceae	*Manihot esculenta* Crantz	C	Shrub	Tuber	78	0.78	1	W: 100%
Fabaceae	*Phaseolus vulgaris* L.	C	Herb	Pod and seed	40	0.40	1	L: 100%
Fabaceae	*Pisum sativum* L.	C	Herb	Pod and seed	9	0.09	1	L: 100%
Fabaceae	*Arachis hypogaea* L.	C	Herb	Seed	2	0.02	1	L: 100%
Fabaceae	*Vigna unguiculata* (L.) Walp.	C	Herb	Pod and seed	2	0.02	1	L: 100%
Fabaceae	*Phaseolus lunatus* L.	C	Herb	Pod and seed	1	0.01	1	L: 100%
Fabaceae	*Psophocarpus tetragonolobus* (L.) DC.	C	Herb	Pod and seed	1	0.01	1	L: 100%
Fagaceae	*Castanopsis evansii* Elmer	W	Tree	Seed	1	0.01	1	L: 100%
Lauraceae	*Persea americana* Mill.	C	Tree	Fruit	10	0.10	1	OF: 100%
Malvaceae	*Durio zibethinus* L.	C	Tree	Fruit	6	0.06	1	OF: 100%
Malvaceae	*Abelmoschus esculentus* (L.) Moench	C	Herb	Fruit	2	0.02	1	OV: 100%
Malvaceae	*Corchorus capsularis* L.	C	Herb	Leaf and shoot	1	0.01	1	G: 100%
Malvaceae	*Theobroma cacao* L.	C	Tree	Fruit	1	0.01	1	OF: 100%
Meliaceae	*Dysoxylum parasiticum* (Osbeck) Kosterm.	C	Tree	Fruit	25	0.25	1	OF: 100%
Meliaceae	*Sandoricum koetjape* (Burm.f.) Merr.	C	Tree	Fruit	4	0.04	1	OF: 100%
Moraceae	*Artocarpus heterophyllus* Lam.	C	Tree	Fruit	64	0.64	2	OV: 100%; OF: 100%
Moraceae	*Artocarpus odoratissimus* Blanco	C	Tree	Fruit	12	0.12	1	OF: 100%
Moringaceae	*Moringa oleifera* Lam.	C	Shrub	Leaf	1	0.01	1	G: 100%
Musaceae	*Musa* sp.	C	Herb	Fruit	136	1.36	2	W: 100%; OF: 100%
Myrtaceae	*Psidium guajava* L.	C/W	Tree	Fruit	25	0.25	1	OF: 100%
Myrtaceae	*Syzygium samarangense* (Blume) Merr. and L.M.Perry	C	Tree	Fruit	4	0.04	1	OF: 100%
Myrtaceae	*Syzygium aqueum* (Burm.f.) Alston	C	Tree	Fruit	1	0.01	1	OF: 100%
Phyllanthaceae	*Breynia androgyna* (L.) Chakrab. & N.P.Balakr.	C	Shrub	Leaf	1	0.01	1	G: 100%
Poaceae	*Oryza sativa* L.	C	Herb	Seed	15	0.15	1	C: 100%
Poaceae	*Cymbopogon citratus* (DC.) Stapf	C	Herb	Leaf	10	0.10	1	S: 100%
Poaceae	*Coix lacryma-jobi* L.	C	Herb	Seed	6	0.06	2	C: 100%; S: 100%
Poaceae	*Saccharum officinarum* L.	C	Herb	Stem	3	0.03	1	S: 100%
Poaceae	*Zea mays* L.	C	Herb	Seed	79	0.79	1	C: 100%
Rubiaceae	*Coffea canephora* Pierre ex A.Froehner	C	Shrub	Seed	48	0.48	1	S: 100%
Rutaceae	*Citrus maxima* (Burm.) Merr.	C	Tree	Fruit	16	0.16	1	OF: 100%
Rutaceae	*Citrus* × *aurantiifolia* (Christm.) Swingle	C	Tree	Fruit	9	0.09	1	OF: 100%
Rutaceae	*Citrus* × *aurantium* L.	C	Tree	Fruit	2	0.02	1	OF: 100%

(*continued on next page*)

Table 3 (*continued*)

Botanical family	Scientific name	Source	Life-form	Edible part	UR	UV	NU	FL
Rutaceae	*Citrus × microcarpa* Bunge	C	Shrub	Fruit	1	0.01	1	OF: 100%
Salicaceae	*Pangium edule* Reinw.	W	Tree	Fruit	1	0.01	1	OF: 100%
Sapindaceae	*Nephelium lappaceum* L.	C	Tree	Fruit	9	0.09	1	OF: 100%
Sapotaceae	*Chrysophyllum cainito* L.	C	Tree	Fruit	7	0.07	1	OF: 100%
Solanaceae	*Solanum americanum* Mill.	W	Herb	Leaf and shoot	17	0.17	1	G: 100%
Solanaceae	*Solanum melongena* L.	C	Herb	Fruit	11	0.11	1	OV: 100%
Solanaceae	*Solanum aethiopicum* L.	C	Herb	Fruit	9	0.09	1	OV: 100%
Solanaceae	*Capsicum annuum* L.	C	Herb	Fruit, leaf, and shoot	15	0.15	3	VA: 100%; G: 50%; S: 100%
Solanaceae	*Solanum lycopersicum* L.	C	Herb	Fruit	2	0.02	1	OV: 100%
Solanaceae	*Solanum tuberosum* L.	C	Herb	Tuber	1	0.01	1	W: 100%
Zingiberaceae	*Amomum muricarpum* Elm.	W	Herb	Fruit	6	0.06	1	OF: 100%
Zingiberaceae	*Etlingera elatior* (Jack) R.M.Sm.	W	Herb	Inflorescence	6	0.06	1	OF: 100%
Zingiberaceae	*Hornstedtia conoidea* Ridl.	W	Herb	Fruit	6	0.06	1	OF: 100%
Zingiberaceae	*Zingiber officinale* Roscoe	C	Herb	Rhizome	4	0.04	1	S: 100%
Zingiberaceae	*Curcuma longa* L.	C	Herb	Rhizome	1	0.01	1	S: 100%
Zingiberaceae	*Hornstedtia lophophora* Ridl.	W	Herb	Fruit	1	0.01	1	OF: 100%

Note: UR, use-report; UV, use-value; NU, number of uses; FL, fidelity level; W, wild plant; C, cultivated plant; C, cereals; W, white roots, tubers, plantains; VA, vitamin A-rich vegetables; G, green leafy vegetables; OV, other vegetables; VF, vitamin A-rich fruits; OF, other fruits; L, legumes, nuts, and seeds; S, spices, condiments, and beverages.

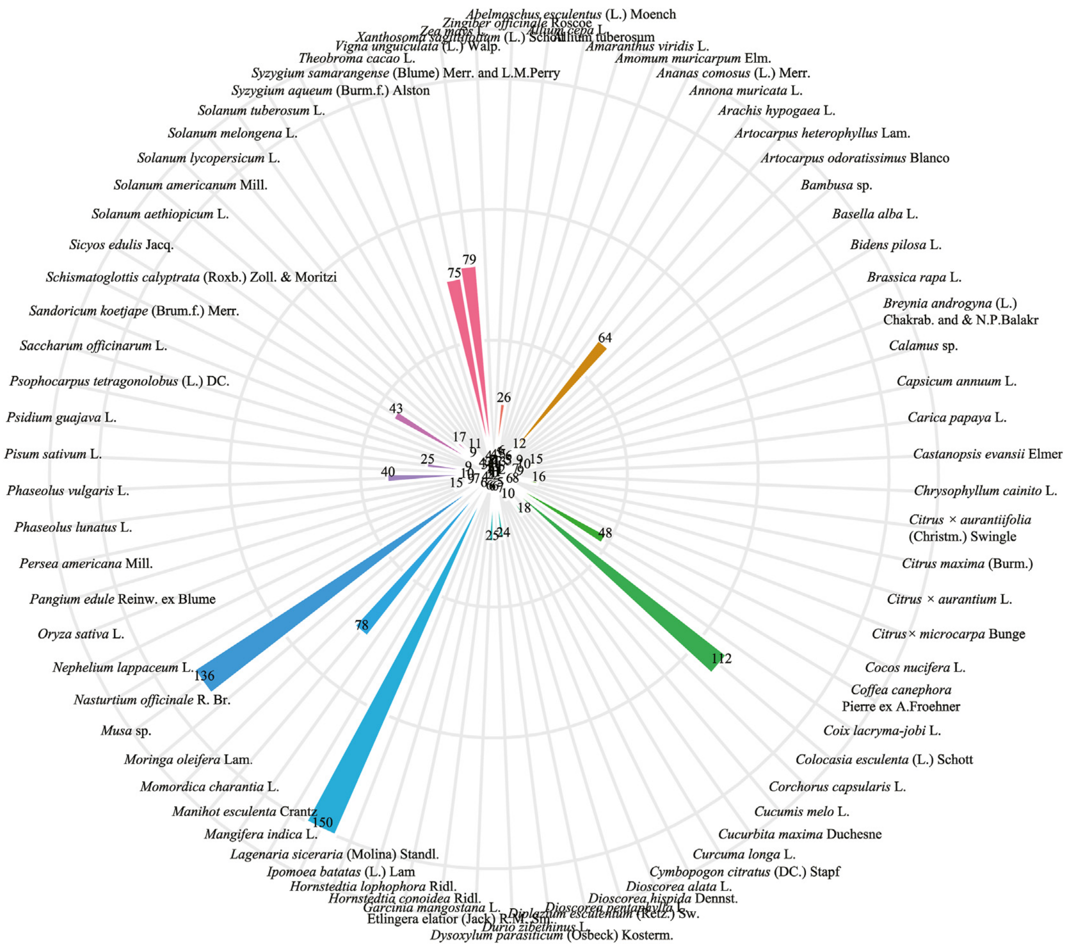

Fig. 4. Radial plot showing the use-values (UVs) of the 76 edible plant species in the Higaonon tribe. The length of ray represents the size of the value, i.e., the species with the highest UV has the longest ray while the species with the lowest UV has the shortest ray.

(UR = 136, UV = 1.36), *Colocasia esculenta* (L.) Schott (UR = 111, UV = 1.11), *Zea mays* L. (UR = 79, UV = 0.79), *Manihot esculenta*

Crantz (UR = 78, UV = 0.78), *Xanthosoma sagittifolium* (L.) Schott (UR = 76, UV = 0.76), *Artocarpus heterophyllus* Lam. (UR = 64, UV = 0.64), *Coffea canephora* Pierre ex A.Froehner (UR = 48, UV = 0.48), *Sicyos edulis* Jacq. (UR = 43, UV = 0.43), and *Phaseolus vulgaris* L. (UR = 40, UV = 0.40). Further, the species with the least UR (1) and UV (0.01) included *Hornstedtia Lophophora* Ridl., *Pangium edule* Reinw. Ex Blume, *Schismatoglottis calyptrata* (Roxb.) Zoll. & Moritzi, *Castanopsis evansii* Elmer, etc. (Table 3).

Most of the respondents reported similar use(s) for edible plant species with the FL of 100%, except for 4 species. For *S. edulis* (chayote), *C. annuum* (chili), and *Cucurbita maxima* Duchesne (squash), all the respondents reported the utilization of their fruits as vegetables (FL = 100% for the 3 species), but very few mentioned the use of their leaves as green leafy vegetables with the FL values of 13.16% (chayote), 50% (chili), and 20% (squash), respectively. *Calamus* sp. (rattan), on the other hand, was mainly consumed as vegetable (FL = 100%), however, a few respondents reported the consumption of its fruits (FL = 50%). *C. annuum* had the highest NU value (3), followed by *A. cepa*, *A. heterophyllus*, *Calamus* sp., *C. lacryma-jobi*, *C. esculenta*, *Musa* sp., *I. batatas*, and *S. edulis*, with NU value of 2. All the other plant species were of single-use. According to the respondents' reports, we further adopted an alluvial diagram to depict the frequency distribution of the 76 edible plant species across the 9 use-categories (Fig. 5).

Seventeen edible plant species were commonly reported in the 5 villages (Fig. 6). These included *Z. mays*, *Citrus maxima* (Burm.) Merr., *C. canephora*, *I. batatas*, *Solanum americanum* Mill, *Dysoxylum parasiticum* (Osbeck) Kosterm., *Artocarpus odoratissimus* Blanco, *P. vulgaris*, *S. edulis*, *M. esculenta*, *Musa* sp., *A. heterophyllus*, *X. sagittifolium*, *Carica. papaya* L., *C. maxima*, *C. esculenta*, and *Psidium guajava* L.

4.4. Variation in edible plant knowledge by gender

Irrespective of villages and plant collection sites (i.e., farms, homegardens, communal areas, etc.), the number of reported edible plant species by males (mean = 13.19) was significantly higher (P = 0.000) than that by females (mean = 9.38) (Table 4). Males' knowledge for edible plant species collected from the forests (P = 0.010) and communal areas (P = 0.022) was significantly higher than females. However, there was no significant difference in the knowledge between males and females for edible plant species collected from homegardens (P = 0.529), along river banks (P = 0.556), and farms (P = 0.383) (Table 4).

Apart from the homegardens (P = 0.029), there was no significant difference in the knowledge associated with the different collection sites among the 5 villages (Table 5). This suggests that most of the edible plant species collected from farms, communal areas, forests, and river banks were ubiquitous species reported in all the 5 villages.

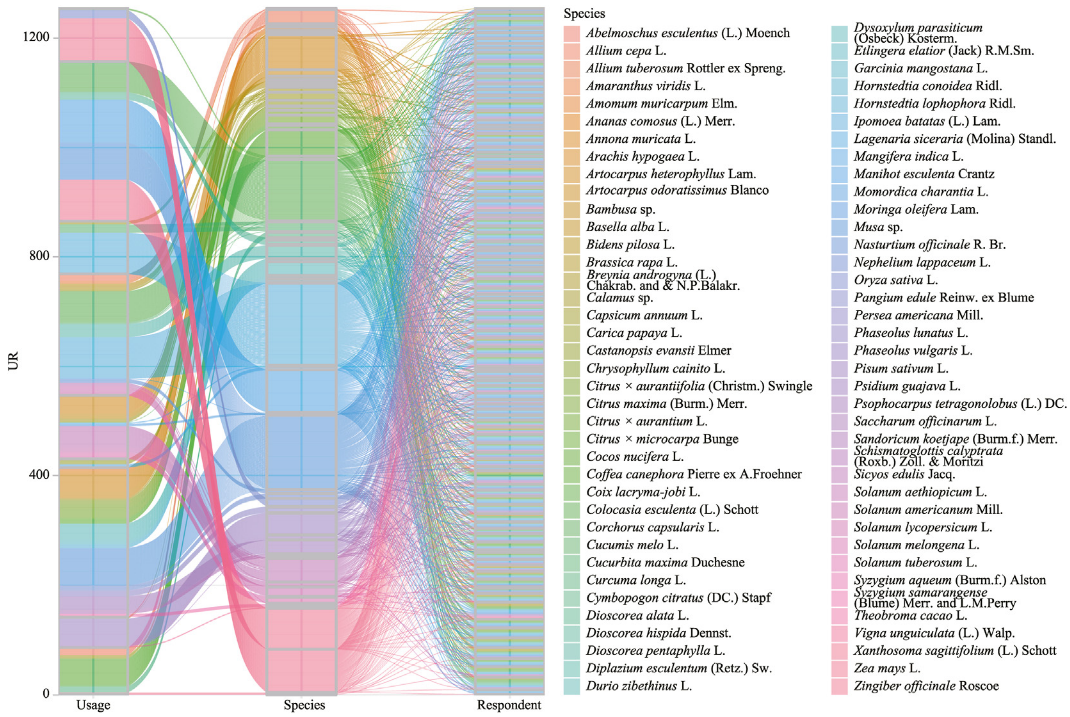

Fig. 5. Alluvial diagram showing the frequency distribution of the 76 edible plant species across the 9 use-categories.

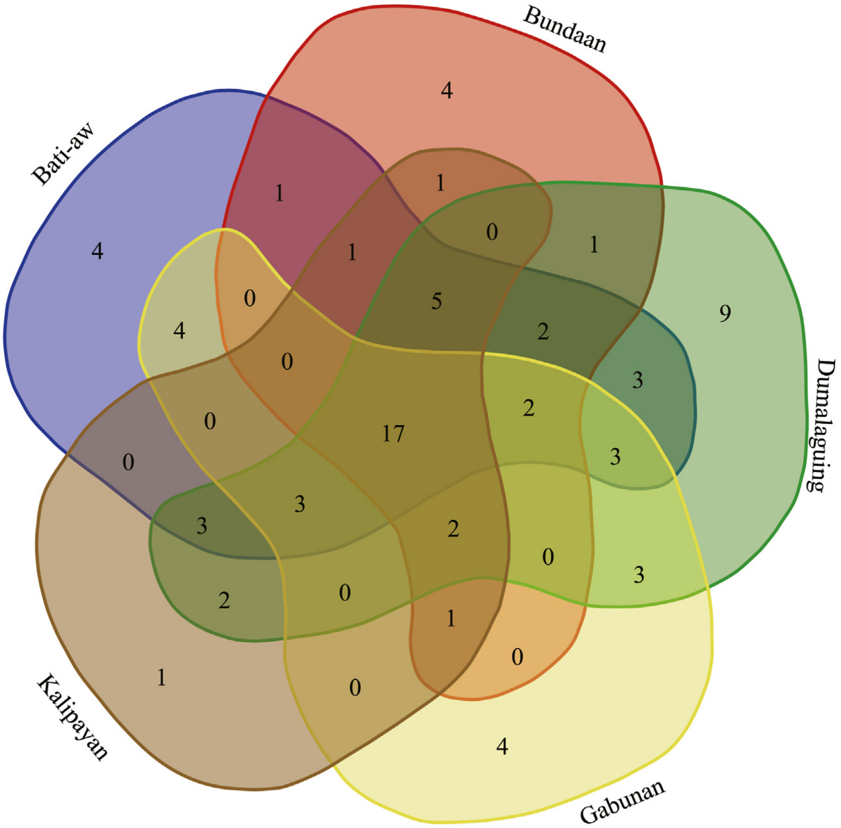

Fig. 6. Venn diagram showing the species richness and distribution of the 76 edible plant species in the 5 villages of the Higaonon tribe. The different values represent the number of edible plant species shared among the 5 villages.

Table 4
Comparison of knowledge for edible plant species between males and females in the Higaonon tribe.

Knowledge about edible plant species	Gender	Mean	SD	SEM	*P*-value
Number of reported edible plant species	Female	9.38	3.60	0.42	0.000
	Male	13.19	4.78	0.94	
Number of reported edible plant species collected from farm	Female	6.36	3.18	0.37	0.383^{ns}
	Male	7.00	3.16	0.62	
Number of reported edible plant species collected from homegarden	Female	2.78	2.57	0.30	0.529^{ns}
	Male	3.19	3.49	0.68	
Number of reported edible plant species collected from communal area	Female	0.38	1.00	0.12	0.022
	Male	1.42	2.12	0.42	
Number of reported edible plant species collected from forest	Female	0.04	0.20	0.02	0.010
	Male	2.08	3.72	0.73	
Number of reported edible plant species collected from river bank	Female	0.01	0.12	0.01	0.556^{ns}
	Male	0.00	0.00	0.00	

Note: There were 74 female respondents and 26 male respondents. SD, standard deviation; SEM, standard error of mean; ^{ns}, non-significance.

5. Discussion

5.1. Botanical diversity of the Higaonon food system

Fabaceae, Cucurbitaceae, Malvaceae, Solanaceae, Zingiberaceae, Poaceae, and Rutaceae are the most species-rich botanical families in the Higaonon food system. This may be explained by the fact that Fabaceae is the world's largest group of edible plants composed of approximately 625 edible species (Antonelli et al., 2020). Apart from the legumes, Solanaceae is also one of the largest groups of edible plants which include some of the most important staple foods such as potato, capsicum, tomato, and aubergine (Samuels, 2015). Several domesticated members of Zingiberaceae are likewise utilized as food or food additives (i.e., spices, flavoring agents, etc.) in many parts of the world (Rachkeeree et al., 2018). Cucurbitaceae includes a wide array of cultivated vegetables that are commonly consumed in

Table 5
Comparison of knowledge for edible plant species associated with different collection sites in the 5 villages of the Higaonon tribe.

	Source of variation	Sum of squares	df	Mean square	*F*-value	*P*-value
Knowledge of edible plant species in 5 villages	Between villages	54.87	4	13.717	0.748	0.562^{ns}
	Within village	1742.44	95	18.342		
	Total	1797.31	99	–		
Farm	Between villages	54.59	4	13.648	1.376	0.248^{ns}
	Within village	942.32	95	9.919		
	Total	996.91	99	–		
Homegarden	Between villages	83.71	4	20.927	2.816	0.029
	Within village	706.08	95	7.432		
	Total	789.79	99	–		
Communal area	Between villages	5.32	4	1.330	0.627	0.644^{ns}
	Within village	201.43	95	2.120		
	Total	206.75	99	–		
Forest	Between villages	32.86	4	8.214	1.972	0.105^{ns}
	Within village	395.65	95	4.165		
	Total	428.51	99	–		
River bank	Between villages	0.05	4	0.013	1.330	0.264^{ns}
	Within village	0.94	95	0.010		
	Total	0.99	99	–		

Note: *df*, degree of freedom; ^{ns}, non-significance; -, no data.

many parts of the world (i.e., bitter gourd, chayote, squash, etc.) (Rolnik and Olas, 2020). Other species-rich plant groups like Poaceae (314 edible species worldwide) and Malvaceae (257 edible species worldwide) (Antonelli et al., 2020), are also extensively utilized in the Higaonon food system. Citrus under the Rutaceae family is amongst the most ubiquitous fruit trees in the world (Ollitrault and Navarro, 2012), and is also the most species-rich fruit group in this study.

5.2. Ethnobotanical utilization of edible plants in the Higaonon tribe

Quantitative ethnobotanical analysis showed that edible plant species belonging to the category of white roots, tubers, and plantains are the most valued crops for the Higaonon tribe. It includes several important carbohydrate sources such as sweet potato, banana, taro, and yautia. The utilization of these starch-rich edible plants is similar throughout the 5 villages (FL = 100%). Subsistence agriculture is fundamental to the Higaonon tribe's indigenous practice, and the aforementioned plants are amongst the primary staple foods of the early indigenous communities in the Bukidnon uplands (Cole et al., 1956; Lynch, 1967). In the 1800s, aside from the different types of roots and tubers, rice has been the foremost staple crop in the Bukidnon uplands (Cole et al., 1956; Lynch, 1967). In fact, rice is integrated into the Higaonon tribe's customary practices like weddings and farming rituals (Cole et al., 1956). The high proportion of corn consumption over rice as the chief cereal crop in the modern-day may have been a biocultural adaptation, particularly during the food-deficit years when the upland village population simultaneously expanded. Historically, the cultivation of corn only expanded in the 19th century from the Visayas to Mindanao, and it became a local staple food in some regions after World War II (Spencer, 1975). Since the yield of corn is greater than that of millet in dry-soil areas that cannot grow rice, corn cultivation becomes a more important component of food supplies necessary to support the rapid growth of the population in the Visayas region (Spencer, 1975). At present, corn is the most important cereal crop of the Higaonon tribe. Locally known as "bugas-mais" ("corn rice"), it is coarsely ground corn that is cooked similar to rice and is often eaten with cooked vegetables. Another noteworthy edible plant in the Higaonon tribe is the "Lab-o" (*Dioscorea hispida* Dennst.), a highly poisonous yam that requires labor-intensive processing to be safe for human consumption. Traditionally, the Higaonon tribe gathers yam from forests and usually treats yam as an important food source during hard period or "tigkabagol" (Buenavista et al., 2021).

Biocultural adaptation is vital to the resilience of the upland communities considering the limited availability of market foods. In this context, resilience is defined as the ability of the indigenous Higaonon communities to cope with social and cultural disintegration (Cullen, 1979; Edgerton, 1983), socio-economic stress (Sealza, 1984; Lao, 1987; Imbong, 2021), and landscape change (Poffenberger and McGean, 1993; Huesca, 2016) in the Bukidnon uplands.

Aside from improving food security, diversification of staple foods can also be an important factor in climate-smart agriculture (Narciso and Nyström, 2020; Ulian et al., 2020). The Higaonon food system consisting of corn, plantains, roots, tubers, vegetables, and fruits can be considered as an adaptive strategy considering the biophysical constraints of rice production in the mountainous Higaonon villages. Among the 5 villages, rice cultivation was only observed in the village of Bundaan. The terraced rice paddy is irrigated using "sandayung", bamboo poles connected from end to end, which draws the water from the mountain. This indigenous strategy of bringing water from forested mountain areas to rice terraces is also practiced by other indigenous groups, such as the Hani people of China (Yang et al., 2018), the Ifugao of northern Philippines (Camacho et al., 2016), and the Hmong ethnic group of Vietnam (Turner, 2012).

Moreover, coffee (*C. canephora*; UR = 48, UV = 0.48) is the most widely consumed beverage (FL = 100%), apart from the traditional rice wine made from fermented rice or Job's tears (*C. lacryma-jobi*; UR = 6, UV = 0.06). The most cited plants also include vegetables such as *S. edulis* (UR = 43, UV = 0.43), *P. vulgaris* (UR = 40, UV = 0.40), and *Diplazium esculentum* (Retz.) Sw. (UR = 24, UV = 0.24), as well as fruits like *D. parasiticum* (UR = 25, UV = 0.25) and *P. guajava* (UR = 25, UV = 0.25). *A. heterophyllus* (UR = 64, UV = 0.64) is eaten as a vegetable when unripe and as a fruit when fully ripened. Out of the 76 edible plant species, 57 species (75.00%) are cultivated species and 16 species (21.00%) are categorized as wild species. Yet, some farms and forested areas are inaccessible due to remoteness and security concerns, which resulted in some uncertainties in the taxonomic identification of some wild plant species collected from the forests. The rattan or "uway", for instance, may be comprised of several species but was collectively identified as *Calamus* sp. in this study. At least 59 species of *Calamus* is known to occur in the Philippines (Baja-Lapis, 2010). Three species (3.9%) that have both wild and cultivated populations: taro (*Colocasia esculenta*, yautia (*X. sagittifolium*), and guava (*P. guajava*) are generally cultivated in homegardens and farms, but some villagers collect wild populations growing naturally in communal areas.

When compared to other ethnic and cultural groups, the Higaonon food system composed of 76 plants species is exceptionally diverse. The diverse ethnic minorities (i.e., Ossetians, Georgians, Udis, etc.) in Caucasus, for example, collectively use only 46 plant species (Pieroni et al., 2020); while the Angami Nagas in India only utilize 29 plant species (Singh and Teron, 2017; Hegazy et al., 2020). The ethnic Fur people of Sudan, on the other hand, make use of only 27 edible plant species. Moreover, In the tribal region of the Himalaya, the ethnic Bhangalis only exploit 50 plant species (Thakur et al., 2017). As such, the Higaonon food system could provide new insights on the potential economic use of neglected and underutilized species.

5.3. Potential nutritional contribution of various staple crops in the Higaonon tribe

Some health concerns of many Filipinos can be attributed to the less diversified and rice-centered diet (Angeles-Agdeppa et al., 2019). In fact, the 2015 country-wide survey has shown that many Filipinos are malnourished and affected of micronutrient deficiencies (i.e., such as vitamin A- and iodine-deficiency disorders and anemia) (Department of Science and Technology-Food and Nutrition Research Institute of Republic of the Philippines, 2015; Capanzana and Aguila, 2020). This national health issue may be addressed by improving the typical Filipino diet with nutrient-rich supplemental or alternative food sources. The wealth of agrobiodiversity and wild edible plants from the biocultural refugia of the Higaonon tribe could provide significant ethnobotanical information regarding the uses of various food plants relevant to the aim of achieving SDG 2.

When compared with other staple crops (Table 6), corn grits locally known as "bugas-mais" can provide more than twice the amount of energy and protein available in rice. Cooked banana and taro can also be a good source of protein and energy. Moreover, the yellow variety of sweet potato and banana can be an alternative or supplemental source of carbohydrates. In terms of vitamin and mineral contents, several staple crops also have higher values than rice. The consumption of corn grits, yautia, and taro could enrich the typical Filipino diet with calcium, phosphorus, and iron. On the other hand, sweet potato (yellow variety) and banana could also provide higher amount of vitamins that may be unavailable or in trace amount in rice, especially the β-carotene (precursor of vitamin A) (Strobel et al., 2007; Grune et al., 2010). As such, considering the dietary strategy of diversifying food and nutritional sources with alternative and supplemental staple crops are helpful to the increasing health concern on the emerging diet- and lifestyle-linked non-communicable chronic diseases (Sarkar et al., 2020).

As an underground crops, root and tuber crops can also contribute to the resilience of local communities affected by natural calamities. In typhoon-affected areas in the Philippines, for example, cultivating root and tuber crops does not only provide food and nourishment but it also lessens the need of spending household incomes and requests for support and assistance from various networks (Gatto et al., 2021).

As with other remote communities, the variety of edible plant species, along with the rich indigenous knowledge are important in resiliency and food security (Giraldi and Hanazaki, 2014; Bvenura and Afolayan, 2015; Quave and Pieroni, 2015; Ferguson et al., 2017). Unfortunately, some of these important edible plants are often neglected and underutilized species. Within the Higaonon food system, some neglected and underutilized species, based on the list of Ulian et al. (2020) include *A. heterophyllus*, *Bambusa* sp., *C. lacryma-jobi*,

Table 6
Nutrient compositions of the selected staple crops as alternative and/or supplemental food sources to rice.

	Rice	Corn grits	Cassava	Yautia	Sweet potato (yellow variety)	Banana	Taro
Composition							
Energy (kcal)	129	350	111	122	128	159	105
Protein (g)	2.1	7.7	0.4	0.8	0.5	1.2	1.5
Total fat (g)	0.2	0.8	0.1	0.1	0.3	0	0.1
Total carbohydrate (g)	29.7	78.1	27.1	29.4	30.7	38.6	24.4
Minerals							
Calcium (mg)	11	22	10	38	30	19	37
Phosphorus (mg)	36	213	22	53	26	37	41
Iron (mg)	0.6	1.3	0.3	1.5	0.4	1.1	0.7
Sodium (mg)	3	1	4	24	43	2	11
Fat-soluble vitamins							
β-carotene (μg)	0	65	0	0	280	170	5
RAE (μg)	0	5	0	0	23	14	0
Water-soluble vitamins							
Vitamin B1 (mg)	0.02	0.14	0.03	0.01	0.04	0.05	0.08
Vitamin B2 (mg)	0.02	0.03	0.01	0.03	0.02	0.04	0.01
Niacin (mg)	0.5	1.3	0.4	0.5	0.3	0.7	1
Vitamin C (mg)	0	0	22	5	14	25	6

Note: The data are from the Philippine Food Composition Tables Online Database of the Food and Nutrition Research Institute of the Department of Science and Technology (https://i.fnri.dost.gov.ph/login/homepage). RAE, retinol activity equivalent.

C. esculenta, *Etlingera elatior* (Jack) R.M.Sm., *Moringa oleifera* Lam., and *Solanum aethiopicum* L. The Higaonon tribe also consumes wild fruits and vegetables which may be considered as neglected and underutilized species locally. These include *D. hispida*, *Dioscorea pentaphylla* L., *S. calyptrata*, *Calamus* sp., *C. evansii*, *P. edule*, *Hornstedtia conoidea*, and *H. lophophora*. The aforementioned edible foods are harvested in the forests and the communal areas in the villages. These neglected and underutilized species have unexploited potential as an alternative and/or supplemental source of nutrients that could help transform food systems to combat malnutrition, hunger, poor health, and even starvation (Padulosi et al., 2013; Baldermann et al., 2016; Hunter et al., 2019; Mustafa et al., 2019; Ulian et al., 2020).

5.4. Edible plant knowledge by indigenous peoples in the Bukidnon uplands

Traditionally, both male and female members of the Higaonon tribe participate in farming and home gardening as these activities provide income and subsistence for the Higaonon family; hence, as predicted, there is no significant difference in the plant knowledge between males and females. Yet, males appeared to be more knowledgeable than females in terms of plant species harvested from the forests and communal areas. This findings could be explained by the prevailing gender roles in farming community in the Bukidnon uplands that ascribes heavier loads to males and lighter work to females (Chiong-Javier, 2012). For the Higaonon tribe, certain tasks are gender-specific like wildlife hunting, harvesting of fruits, wild vegetables, and other non-timber products in the forests which are exclusively done by males (Cole et al., 1956).

In other ethnic groups and cultural minorities, the task of foraging in the forest is also designated to men such as the Agta of Luzon, the Philippines (Hagen et al., 2016) and the Laklãnõ-Xokleng peoples of southern Brazil (Heineberg and Hanazaki, 2019). However, in other ethnic groups, some studies also showed that gender does not influence knowledge of plants such as the research findings on the Mayans in Guatemala (Turreira-García et al., 2015) and the indigenous Rarámuri of Mexico (Camou-Guerrero et al., 2008). Therefore, the influence of gender on plant knowledge may be explained by the tribe's social organization as well as the specific food biocultural refugium where the edible plants are harvested. On the other hand, the significant difference in plant knowledge associated with homegardens could be due to the varying size of plots and species diversity of homegardens that vary in every household and village. Moreover, due to proximity of certain households to the lands they cultivate, some Higaonon households do not have homegardens or have less diverse plant species. However, the size of homegarden plots, species diversity, and species abundance were not covered in this study and should be considered for in future research.

6. Conclusions

The Higaonon food system consists of diverse nutrient-rich edible plants: 76 species belonging to 62 genera and 36 botanical families. The richness of agrobiodiversity and wild edible plants is vital for the food security and resilience of the Higaonon tribe since the mountainous terrain of Bukidnon Province presents a challenge for rice cultivation. Due to limited irrigated agricultural land and expanding populations in the Bukidnon uplands, the Higaonon food system shifted from a rice-centered diet into more diverse staple crops such as sweet potato, yautia, taro, corn, cassava, and banana. The Higaonon tribe also exploited other rice substitutes, such as Job's tears, wild yams, and other neglected and underutilized edible plants. Whilst males appeared to be more knowledgeable of edible plant species collected from forests and communal areas, there were no significant differences between males and females in terms of knowledge of edible plants collected from homegardens, riverbanks, and farms. The various collection sites of the Higaonon tribe could be considered as food biocultural refugia given their socio-ecological function in food security, agrobiodiversity, and biocultural preservation of indigenous knowledge. As such, and in partnership with indigenous peoples, we recommend the ethnobotanical documentation and evaluation of the dietary value of local flora in other islands of the Philippines. In line with the Philippines' goal of achieving the UN SDG 2 (zero hunger), the potential economic utilization and promotion of neglected and underutilized plant resources should be further explored for developing nutrition-sensitive food systems and value-chains, and building rural communities.

Disclaimer

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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