

# Significance of *Sphenoclea Zeylanica* as a Food Resource in Twenty-first Century Urban Bali, Indonesia

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## Research

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# Abstract

## ***Background***

Diversifying food sources by including edible wild plants or weeds as food resources can help to combat the issues of simplified diets and food security in the modern world. The present study investigated the case of *Sphenoclea zeylanica* Gaertn. (gooseweed or wedgewort), an edible wild plant with traces of historical consumption in Indonesia. Because previous studies have failed to clarify its significance for consumption by society, the present study aimed to clarify the significance of *S. zeylanica* as a food resource in the 21st century.

## ***Methods***

Data were collected in Bali Province (Denpasar City and Timpag Village, Tabanan Regency) through interviews with a farmer, direct field visits to wet markets and supermarkets, and an online questionnaire. Supply distribution was analyzed using geographical information system mapping to visualize point data density, while statistical significance of consumption data was analyzed using the R software.

## ***Results***

The results showed that *S. zeylanica* was cultivated as a vegetable crop by local farmers in Timpag Village from 2014. Fresh *S. zeylanica* could be found mainly sold in wet markets within Denpasar City, while prepared or cooked versions of the plant were noted to be sold in several food and beverage establishments. The selling price of *S. zeylanica* was also found to be high among other similar vegetables.

A majority of the study's survey respondents have consumed *S. zeylanica* at least once in the past, with most of them tended to be older and were more often female. However, it was identified that factors such as low production, unequal distribution, and high market pricing were probable causes in limiting its use and consumption.

## ***Conclusions***

It was concluded that *S. zeylanica* has limited significance in 21st century urban Bali, Indonesia, despite high awareness of the plant as a food resource. However, commercialization and preservation of cultural plant knowledge surrounding *S. zeylanica* were thought to be potentially important actions for maintaining its use as a future food resource. Consequently, further research is necessary on potential marketing methods and strategies to generate greater interest or demand towards *S. zeylanica* as a vegetable crop.

# Background

Simplification of diets has been highlighted as a major issue in the modern world, resulting from globalization, industrial agriculture, rural poverty, population pressures, and urbanization (FAO, 2010). It is characterized by a high reliance on a limited number of high energy foods, which focuses on the consumption of certain domesticated cereals (e.g., maize, rice, wheat, barley), tubers (e.g., potato, cassava, yam), and meats (e.g., beef and chicken). Consequently, this increasing reliance on few domesticated species as a food resource has the potential to pose a major threat to global food security (Grivetti and Ogle 2000; Khoury et al. 2014).

Diversifying food sources has been discussed as a measure to combat food security (Faber et al. 2017; Fentahun and Hager 2009; Massawe et al. 2016). Although this can be achieved by sourcing and consuming more varieties of domesticated plant and animal species, edible wild species have also been noted as contributors (Bvenura and Afolayan 2015; Degreef et al. 2016; McCrindle et al. 2013; Molla et al. 2011).

Edible wild plants in particular have been regarded as an emerging food source in the 21st century, and are important as part of new thinking surrounding food that contributes to health and food security (Luczaj et al. 2012). In addition to their common use in traditional medicine (Grivetti 2006), edible wild plants have great potential as a food resource because they can meet a broad range of micronutrient needs (Becker 1983; Glew et al. 1997; Locket et al. 2000). Rural communities in particular have shown how edible wild plants can make key contributions toward macro- and micronutrient intake among their people (Grivetti and Ogle 2000; Scoones et al. 1992).

In Asia, the use of wild plants as a food resource can be traced back to ancient China (Weng and Chen 1996). Later studies found that wild plants were consumed in several other Asian regions, including India (Datta and Banerjee 1978; Narzary and Basumatary 2019), Nepal (Dangol 2008; Joshi et al. 2015), Laos (Kosaka et al. 2006), Vietnam (Ogle et al. 2003), Thailand (Cruz-Garcia and Price 2011; Cruz-Garcia and Struik 2015; Maneechote 2017), and Indonesia (Chotimah et al. 2013; Holm et al. 1977). Notably, although wild plants in these regions are used in cooking and/or in traditional medicine among rural communities, they have also been classified as weeds in agricultural landscapes (Galinato 1999). Therefore, the contribution of wild plants to dietary diversity has been limited to the immediate rural population and farmers who possess direct knowledge of their value.

*Sphenoclea zeylanica* G. (Gaertner), otherwise known as gooseweed or wedgewort, is one of many edible wild plants found in Asia, and is also considered a weed. The plant is an annual herbaceous species that grows 7–150 cm tall with erect stems that are cylindrical and hollow (Holm et al. 1977). Historically, *S. zeylanica* originated from tropical Africa but has spread to over 37 countries within tropical and subtropical regions (CABI 2018). The distribution of *S. zeylanica* in Asia accounts for about 51% (representing a total of 19 Asian countries) of its total global distribution. The plant mainly thrives in damp environments and stagnant waters, such as lowland paddy fields and swamps, and competes heavily with domesticated crops for nutrients in agricultural settings. Past studies have reported that *S.*

*zeylanica* can reduce rice yields between 26 and 50%, indicating their severe effect as weeds (Ghosh and Ganguly 1993; Moorthy and Manna 1985).

As an edible plant, the use of *S. zeylanica* for human consumption was first recorded in 1977 by Holm et al. in Thailand and Indonesia, where it was said to have been steamed and eaten with rice. In a later study during the 21st century, consumption of the plant was also recorded in Assam, northeast India, where it was fried or boiled (Narzary and Basumatary, 2019). Apart from these reports, however, there are few known instances or cases surrounding the usage of *S. zeylanica* as a food resource.

Previous studies have failed to provide an in-depth understanding of the significance of *S. zeylanica* as a food resource in society, with most solely highlighting the way they are consumed. This lack of understanding may further undermine the importance of edible wild plants and their potential contribution towards combating simplified diets and food security. Thus, the present study aimed to clarify the significance of *S. zeylanica* as a food resource in the 21st century through an analysis of consumption and market distribution.

## Methods

### Study area

Based on the documentation by Holm et al. in 1977, Indonesia was chosen as the study area because of known historical traces of *S. zeylanica* consumption. It was later confirmed through local media sources that extensive consumption of *S. zeylanica* was mainly centralized in Bali Province (Setya, 2019; Sotyati, 2018). Consequently, primary data were collected at two main sites within the province: Denpasar City (capital city of Bali Province) and Timpag Village, Tabanan Regency (a primary harvesting site for *S. zeylanica*). The geographical locations of both sites in Bali Province are shown in Fig. 1.

Geographically, Denpasar City is located at 8°40' 13.6488°S and 115°12' 45.4716°E at 0–75 m above sea level. Timpag Village lies northwest of Denpasar City, located 8°28' 55.8948°S and 115°4' 48.6156°E at a higher altitude of 350–500 m above sea level. Under the humid tropical climate of Indonesia, an average annual temperature of 26.7 °C and an average annual rainfall of 1741 mm can be expected around the vicinity of Denpasar City (Climate Data, 2020).

With 78.626 ha out of a total 407.534 ha of agricultural land in Bali Province allocated for rice cultivation, wet rice fields and rice terraces are part of a common cultural landscape along lowland areas and nearby mountain ranges within the province. Active volcanoes present within the Bali Province also contribute to the soil fertility of the environment, which supports the high productivity of agroecosystems. Although cultivated plants dominate the vegetation of the province, tropical and mangrove forests also constitute a large part of its environment.

In 2010, the population of Bali was 3,890,757 (Statistics of Bali Province, 2010). Denpasar City accounted for the highest population share within the province, where about 9% (788,589 people) of the total

population resides. Timpag Village was home to only 3,057 people in the same year. The people of Bali have historically been dependent on agriculture as a main occupation, but mass tourism beginning in the 1970s has shifted a large part of economic activity and employment towards the service or tourism sector (Howe 2006).

## Data collection

An interview with a farmer in Timpag Village, who pioneered the supply of *S. zeylanica* to food markets in Bali Province, was first conducted to better understand the historical background of the plant in the area, its usage by the local rural community, and to clarify distribution channels. Answers from the interview were recorded in writing in May 2019.

After the interview was completed, a set of social surveys was conducted. These surveys included: 1) a market distribution survey (supplier side), and 2) a consumption knowledge survey (consumer side). The market distribution survey was also conducted in May 2019, while the consumption knowledge survey was conducted in July 2019.

The market distribution survey involved direct visits to wet markets and supermarkets within the study area, the locations of these markets were identified through Google Earth prior to confirming the visits. The availability of *S. zeylanica* in these establishments was recorded along with their selling price. The availability and price of other plants and/or vegetables in similar categories (e.g., leafy, herbaceous cultivars) were also noted for comparison. Data from two wet markets (consisting of 16 vegetable vendors) and 18 supermarkets within Denpasar City were collected.

For the consumption knowledge survey, online questionnaires were prepared using Google Forms and distributed to respondents living within and around the vicinity of Denpasar City, based on random sampling. Responses from 150 local Balinese respondents were successfully recorded.

The consumption knowledge questionnaire first asked whether respondents had ever consumed *S. zeylanica*. Respondents who had consumed the plant at least once were permitted to proceed and answer the main questions in the survey, while the survey ended for those who had never consumed *S. zeylanica*. In the main section of the questionnaire, respondents were asked questions regarding their knowledge of *S. zeylanica* as an edible wild plant or weed (yes–no questions) in addition to questions regarding taste (open-ended question with keyword input), consumption methods (multiple-choice question), locations of procurement (open-ended question), and consumption frequency (multiple-choice question).

## Data analysis

Distribution data were visualized using graphical and visual methods. Point data were mapped through the Geographical Information System (GIS) of ArcMap (Version 10.8) to clarify the density of locations in Bali Province that provided *S. zeylanica*.

Data from the consumption knowledge survey were analyzed qualitatively, and visual conversion of quantitative data were presented as graphs. Statistical differences of datasets were analyzed using an independent sample *t*-test and linear regression analyses conducted in the R software.

## Results

### Cultivation and usage of *S. zeylanica* in rural Bali

*S. zeylanica* was cultivated as a vegetable crop by farmers in Timpag Village from 2014, and is commonly called *gonda* or *gunda* by locals. Before this, the plant was mainly foraged as a wild edible plant from lowland paddy fields, when available. *S. zeylanica* was cultivated to raise additional income for farmers between fallow periods in rice farming schedules. The plant was reportedly harvestable up to eight times annually when environmental conditions were favorable (e.g., no occurrence of drought) and crop scheduling went as planned. Annually, a farmer in Timpag Village can harvest between 0.5 and 1 tons of *S. zeylanica* from a 0.01 ha plot of land. Figure 2 shows a rice paddy field in Timpag Village managed by the interviewed farmer, which was later be used to plant *S. zeylanica*.

*S. zeylanica* is cultivated in Timpag Village under organic farming practices, and farmers procure all seeds naturally from mature plants. It can take up to 3 weeks for seeds to grow before they are ready for transplantation to a lowland rice paddy field; another 15 days, or approximately 2 weeks, are needed before the plants can be harvested. In total, about 1 month is needed for the cultivation of *S. zeylanica* from seeds to harvest.

Although *S. zeylanica* is generally perceived to be easily cultivated, attempts to increase production have been a challenge owing to the extensive efforts required. For example, although farmers would like to plant more *S. zeylanica* in their fields, they do not own enough land to do so. Because fields are leased by landowners in Timpag Village, it is necessary for farmers to save money for investment, which can take years to accumulate. Consequently, production of this plant has not increased significantly, despite farmers claiming that demands have increased.

Harvested *S. zeylanica* is sold by farmers in a bundle system, which commonly consists of 15 stalks per bundle. When they are sold to buyers from outside the village (e.g., Denpasar City), one bundle of the plant is normally priced at Rp 1,000.00 (approximately US \$0.065). For buyers from within the village, such as neighbors, special prices can be applied, which range from Rp 10,000.00 (US \$0.65) per 13 bundles to Rp 50,000.00 (US \$3.25) per 65 bundles. There are also separate prices for buyers from food and beverage establishments (e.g., restaurants, small food vendors), who are given a price of Rp 50,000.00/10 large rolls. These large rolls are equivalent in size of approximately 70 bundles of harvested *S. zeylanica*. Since 2014, purchases from restaurants and food establishments have made a greater contribution towards farmers' income than purchases from other buyers.

Locals in Timpag Village noted that *S. zeylanica* is cooked in a variety of ways; the most common method of preparation is steaming. This plant has also been prepared by lightly stir-frying with a

combination of garlic, chili peppers, lime juice, salt, and coconut oil. Less popular and relatively new ways of preparing *S. zeylanica* include frying as *rempeyek* (an Indonesian fried snack) and juicing as a beverage.

## Distribution, pricing, and marketing of *S. zeylanica* in food markets

*S. zeylanica* was sold fresh at the two surveyed wet markets and three out of 18 supermarkets within Denpasar City. The full list of the surveyed locations is shown in Table 1.

In wet markets, fresh *S. zeylanica* was sold by approximately half, or slightly less than half, of all vegetable vendors. Conversely, the plant was rarely stocked in supermarkets; only a few supermarkets managed under the 'Tiara' company group supplied it.

Fresh *S. zeylanica* was priced higher (average Rp 5,857.00 or US \$0.38) in wet markets and lower (average Rp 4,420.00 or US \$0.29) in supermarkets. Table 1 shows that the price of the plant varied between vendors in wet markets, ranging from Rp 4,000.00 to 8,000.00 (US \$0.26–0.52), while prices tended to be stable between supermarkets, ranging from Rp 4,000.00 to 5,000.00 (US \$0.26–0.33). Although the average price of *S. zeylanica* in supermarkets was lower than that of other similar green leafy vegetables, the difference was not statistically significant ( $P > 0.05$ ).

Price comparisons of *S. zeylanica* and other green leafy plant species in surveyed supermarkets revealed three possible groupings of market-valued plants based on observed market prices and their frequency of availability (Fig. 3). Based on these groupings, *S. zeylanica* can be categorized in Group A as a plant with low market price and low availability. However, its price is higher than that of other plants in the group, which includes *Limnocharis flava* (yellow velvetleaf), *Diplazium esculentum* (vegetable fern), and *Ocimum africanum* (lemon basil). Coincidentally, *L. flava* and *D. esculentum* are usually grow in the wild or are considered to be weeds, making them similar to *S. zeylanica* in terms of their unconventional use as food. In contrast, a high market value is placed on *Brassica* spp., with all four varieties being moderately or highly priced, and having moderate-to-high availability among supermarkets.

Plants in the first group (Group A) are characterized by low market prices and low availability; plants in the second group (Group B) are those with high market prices and low-to-moderate availability; plants in the third group (Group C) have low to moderate market prices and high availability. Prices are denoted in Indonesian Rupiah or IDR (Rp 1.00 = US \$0.065).

Excluding the price factor, the presentation and packaging of fresh *S. zeylanica* also differed between those found in the wet market and supermarket. All vendors in wet markets displayed the plant without any packaging, and tied it with an elastic rubber band, while in supermarkets, the plants were wrapped in fresh banana leaves. Furthermore, the visual quality of *S. zeylanica* differed between wet markets and supermarkets, with those sold in wet markers presenting more damage, such as tears, holes, and withering of leaves. Displays of the plant in a wet market and a supermarket are shown in Fig. 4.

Consumption knowledge questionnaires distributed to local Balinese respondents also revealed the distribution of cooked or processed *S. zeylanica*. These plants were found to be distributed among 18 locations across Denpasar City, including restaurants. The geographical distribution of these food service establishments is illustrated in Fig. 5 along with markers that represent the locations of the surveyed wet markets and supermarkets.

Shapes represent restaurants (red circle), wet markets (blue rectangle), and supermarkets (green triangle). Supermarkets where *S. zeylanica* was not available (black triangle) are also shown.

## Consumption patterns of *S. zeylanica* among Balinese locals in urban Bali

In total, 131 of 150 (87.3%) respondents of the consumption knowledge survey reported consuming *S. zeylanica* once in their lifetime. Furthermore, respondents who had consumed the plant tended to be older and were more often female; 100 respondents (76.3%) were aged 30–59 years and 101 (77.1%) were female. In contrast, the remaining 19 respondents who had never consumed the plant were younger, including 18 respondents aged 10–29 years. The reasons given by these respondents included no prior knowledge of the plant (90%), unfamiliarity regarding place of procurement (5%), and no particular interest in consuming the plant (5%).

Knowledge of the plant as a weed was divided, with about half of the 131 respondents who had consumed the plant responding positively. About 51.1% of respondents were aware that the plant is a weed, while 48.9% considered it to be a typically grown vegetable. When asked if they were initially wary to consume the plant due to its weedy nature, a majority of 114 respondents (87%) had no concerns. Out of these 114 respondents, five elaborated that they were not worried about consuming the plant because it is a 'traditional vegetable', a 'traditional food', and/or an 'ingredient used for traditional cooking'. The value of *S. zeylanica* as a traditional vegetable crop was further emphasized by comments from four respondents who were introduced to the plant by their families when they were a child, and five others who claimed its commonality as an edible vegetable in the food markets of Bali.

Plant parts that were commonly consumed based on respondents' answers included the leaves (129 responses; 98.5%) and stems (41 responses; 31.3%), with the flowers being the least consumed (five responses; 3.8%). Furthermore, respondents consumed *S. zeylanica* in three main forms: 1) boiled (107 responses; 81.7%), 2) sautéed (54 responses; 41.2%), and 3) fresh or unprocessed (seven responses; 5.3%). *S. zeylanica* was also consumed to lesser extents by adding to soups, *pepes* (foods cooked in banana leaves), and curries.

Fifty-four of the 131 respondents noted *S. zeylanica* for its bitter flavor. Other notable comments (from six respondents) included descriptions of the plant being similar to other green leafy vegetables in taste (for example *Spinacia oleracea* or spinach, *Ipomea aquatica* or water spinach, and *Brassica rapa* var. *parachinensis* or choy sum) Many responses reported that when *S. zeylanica* was not available, *I. aquatica* was consumed as the main alternative (105 responses; 80.2%), followed by leaves from

*Manihot esculenta* or cassava (53 responses; 40.5%), *Ocimum africanum* or lemon basil (12 responses; 9.2%), *Limnocharis flava* or yellow velvetleaf (five responses; 3.8%), and *S. oleracea* (two responses; 1.5%).

Figure 6 shows where fresh *S. zeylanica* was purchased and where the plant was consumed or cooked, based on multiple choice responses by 131 respondents. *S. zeylanica* was commonly bought fresh in wet markets, while the most common place to consume or cook the plant was at home. Responses indicate that no respondents have been to modern cafes to be served cooked *S. zeylanica*, or that such establishments do not serve the plant.

The frequency of *S. zeylanica* consumption between 2018 and 2019 by the 131 survey respondents is displayed in Fig. 7. The results show the plant was more likely to be consumed monthly than weekly or annually. Furthermore, the most frequent consumers of *S. zeylanica* (those who consume more than three times per week) were aged between 30 and 59 years, while least frequent consumers (those who consumed the plant once per year) were aged between 20 and 39 years. However, a linear regression analysis performed with consumption frequency against the age of respondents showed no significant correlation between the two variables ( $P > 0.05$ ), indicating that consumption frequency does not increase with age.

Respondents who consumed *S. zeylanica* less frequently (monthly and annual basis) reported several reasons why the plant was not consumed more regularly. Fifty-three percent of 74 responses noted that unavailability of *S. zeylanica* in food markets (keywords: “difficult to find,” “not available”) is the primary reason for the infrequent consumption of the plant. The second most common reason was dislike of taste (19%), followed by diet diversification purposes (18%), time or location constraints (8%), and price constraints (3%).

## Discussion

### Factors limiting the significance of *S. zeylanica* as a food resource

Deliberate cultivation of *S. zeylanica* as a vegetable crop by farmers in Timpag Village from 2014 indicated that the plant may be increasing in significance as a food resource in modern Balinese society. Furthermore, its observed availability among several food markets, and consumption by Balinese locals sampled in the study supported the plant’s prevalence among consumers. However, the results also suggested that barriers exist, which may have limited more significant and frequent consumption of *S. zeylanica* by the wider Balinese population.

The limited distribution of *S. zeylanica* seemed to be the main issue underlying the plant’s low availability in food markets. However, it is probable that this was due to a limited supply from producers. As noted above, although farmers faced no issues when cultivating *S. zeylanica* and were able to harvest the plant

multiple times a year, there were constraints to increasing production (i.e., lack of investment for agricultural land expansion). The annual harvest of *S. zeylanica* in Timpag Village (0.5–1.0 tons per 0.01 ha) is small compared to the provincewide production of other leafy green vegetable crops such as *Brassica oleracea* var. *acephala* (kale), which reached 6,683 tons in 2019 (Statistics of Bali Province 2019). Additionally, Timpag Village is currently the only known and largest supplier of *S. zeylanica*; therefore, production and supply constraints may limit the significance of the plant as a food resource in Bali.

Despite supply issues, however, the sparse distribution of *S. zeylanica* in fresh food markets may have prevented the plant from reaching locations where demand for it exists. This is supported by the results in Fig. 5 and Fig. 6, which show a contradiction between where *S. zeylanica* was mostly available (restaurants) and where consumers actually purchased and consumed the plant (wet markets and at home). Although the restaurants serving *S. zeylanica* across Denpasar City are able to widen the access point for consumers, the questionnaire results emphasized that this might not be true. As respondents reported that *S. zeylanica* was still difficult to obtain, regardless of their availability in restaurants, it can be argued that fresh food markets are still the most important place for consumers to acquire the plant. As such, the factor of unequal distribution may have impeded the significance of *S. zeylanica* as a food resource in Bali.

Pricing of *S. zeylanica* may also have limited the plant's significance as a food resource. As shown in Fig. 3, although *S. zeylanica* was not available in most supermarkets, it was still priced higher than other plant species in Group A, and some in Group C. This is arguably a major issue, as almost all alternatives that can replace *S. zeylanica* as a vegetable (namely *I. aquatica*, *O. africanum*, *L. flava*, and *S. oleracea*) were, on average, priced lower. As noted in several studies, prices can play a large role in influencing food purchases, and can especially affect purchasing decisions of vegetables by low-income families (Cassidy et al. 2007; Dong and Lin 2009; Steenhuis et al. 2011). This may have led to *S. zeylanica* being purchased from supermarkets at a low frequency, as shown in Fig. 6. This is partly corroborated by responses from the consumer knowledge survey, which noted price constraints as a cause for lower consumption frequency. However, it is unclear whether consumers would be willing to pay more to purchase and consume *S. zeylanica* from restaurants.

The knowledge of consumers on *S. zeylanica* may not have inhibited its significance as a food resource. The decision to consume *S. zeylanica* was unlikely to have been influenced by knowledge that it is a weed, but was instead affected by taste preferences and dietary purposes (excluding reasons of limited availability). However, there is a concern regarding the lack of knowledge surrounding *S. zeylanica*, which was found among 19 survey respondents who had not yet consumed the plant. Because most of these respondents were aged between 10 and 29 years, it is possible that knowledge relating to the consumption of *S. zeylanica* may erode if it is not passed down as intellectual heritage to the younger generation. Similar trends have previously been observed in Bali (Caneva et al. 2017; Sujarwo et al. 2014a; Sujarwo et al. 2014b) and in other parts of the world (Srithi 2009; Wyndham 2010). This could lead to the permanent loss of valuable and traditional plant knowledge (Sen and Ghosh 2011).

Consequently, it is unclear how the loss of traditional plant knowledge may threaten the demand of *S. zeylanica* in the Balinese market. Thus, erosion of plant knowledge can be considered as a dormant factor that can limit the significance of *S. zeylanica* as a food resource in the future.

## **Future of *S. zeylanica* as a food resource in Balinese society**

Based on the factors identified that may limit the significance of *S. zeylanica* as a food resource in Bali, it is difficult to ascertain whether its prevalence in the future will increase or decrease. At best, consumption of this plant may be preserved in rural areas such as Timpag Village; however, maintaining its relevance as a food resource considering changes and development of modern societies may become a challenge in the future.

Commercialization of *S. zeylanica* as a cash crop by farmers may be one way to raise and maintain the significance of the plant in the long term. This is possible given the experience with *I. aquatica* (water spinach), which has become a vegetable crop with high market throughout many parts of Asia despite its historical traces as a wild edible plant (Eddie and Ho 1969). As described by Eddie and Ho, *I. aquatica* was likely spread and popularized as a vegetable crop from southern China owing to its practicality in cultivation and ease of storage during migration. Although it is unclear how they were introduced into other regions, *I. aquatica* eventually gained importance as a leaf vegetable in South and Southeast Asia, with its cultivation by paddy farmers in Thailand an additional cash crop (Cornelis et al. 1985). The similarity in background between *S. zeylanica* and *I. aquatica*, indicates that *S. zeylanica* has potential as a cash crop, given that there is sufficient marketing to generate an interest and demand. Further studies on ways to effectively market the plant, however, are necessary.

Maintaining the prevalence of *S. zeylanica* as a food resource will also likely depend on the active cultural transmission of ethnobotanical knowledge. Because several respondents in the study were acquainted with *S. zeylanica* as a vegetable from their families, the role of family members in helping to preserve traditional local knowledge must not be ignored. Studies also support the importance of families in disseminating plant knowledge (Lozada et al. 2006; Quinlan et al. 2016; Wyndham 2010). Therefore, communication between family members may help to maintain consumption knowledge of *S. zeylanica* despite generational gaps. Consequently, concerns should be focused on factors that can change or disrupt family structures and communication, such as globalization (Sujarwo 2014b; Trask 2009).

Although efforts to increase and maintain the significance of *S. zeylanica* will be important to diversify food resources and improve the livelihoods of farmers cultivating the plant, caution must also be made not to compensate for the diversity of other possible edible plants in Bali Province.

## **Conclusion**

The present study demonstrated that *S. zeylanica* has limited significance in 21st century urban Bali, Indonesia, due largely to supply factors such as low production, unequal distribution, and high market pricing compared to other similar green leafy vegetable crops. Although there is high awareness on the

plant as a food resource, its future significance in the food system of Bali Province may be threatened through the erosion of plant knowledge among the younger generation.

However, the commercialization of *S. zeylanica* as a cash crop among farmers and the maintenance of cultural knowledge surrounding the plant through dissemination between family members may ensure its long-term significance as a food resource. Further research is necessary to investigate potential marketing methods and strategies that can generate enough interest or demand towards *S. zeylanica* as a vegetable crop.

## **Declarations**

## **Ethics approval and consent to participate**

Not applicable.

## **Consent for publication**

Not applicable.

## **Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## **Competing interests**

Not applicable.

## **Funding**

Not applicable.

## **Authors' contributions**

Not applicable.

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## Table

Due to technical limitations, table 1 is only available as a download in the Supplemental Files section.

## Figures

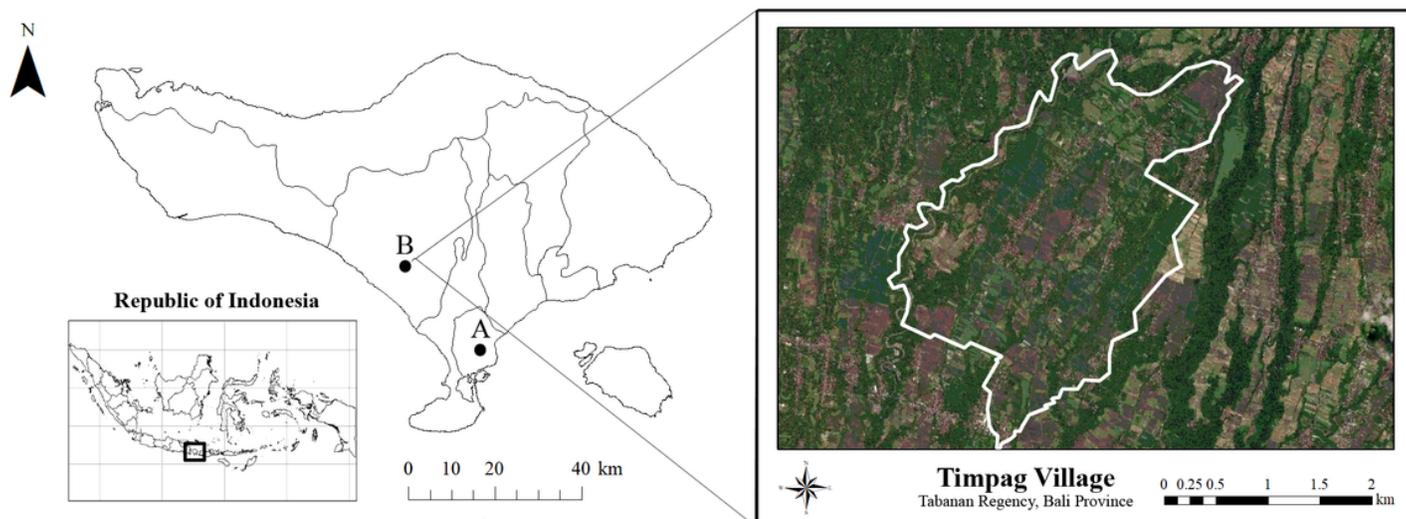


Figure 1

Location map of Denpasar City (A) and Timpag Village (B) in Bali Province, Indonesia.



Figure 2

Rice paddy field (a) owned by the interviewed farmer (b) for planting *Sphenoclea zeylanica*.

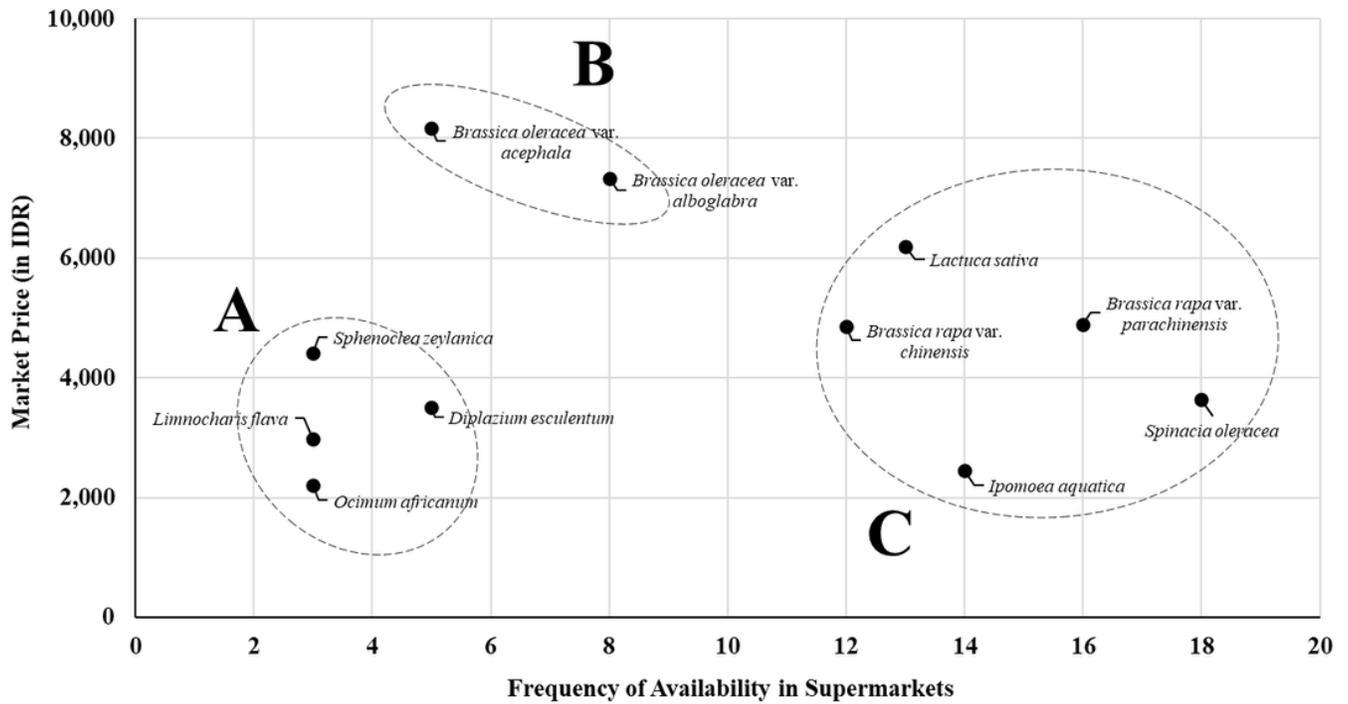


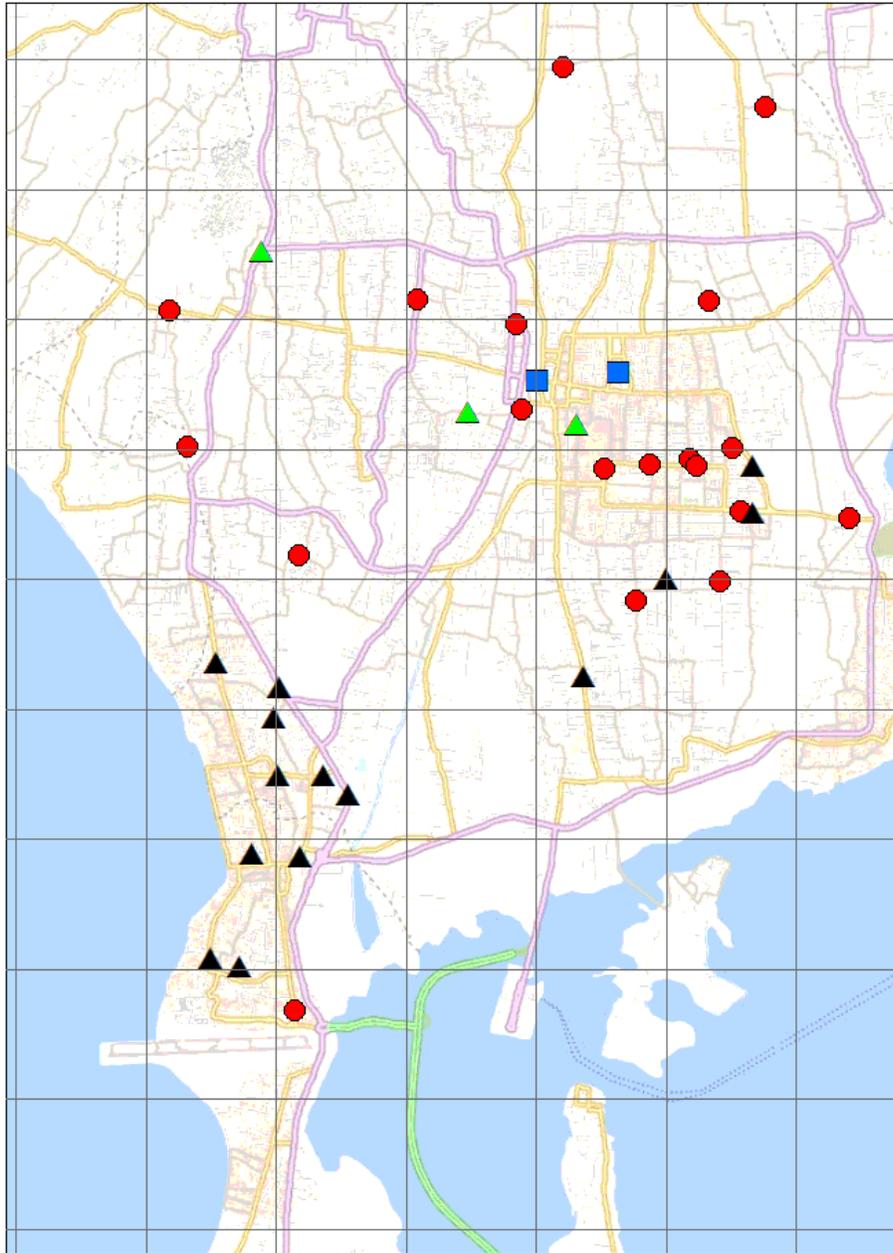
Figure 3

Market value grouping of plant species sold in surveyed supermarkets in Denpasar City, Bali Province. Plants in the first group (Group A) are characterized by low market prices and low availability; plants in the second group (Group B) are those with high market prices and low-to-moderate availability; plants in the third group (Group C) have low to moderate market prices and high availability. Prices are denoted in Indonesian Rupiah or IDR (Rp 1.00 = US \$0.065).



**Figure 4**

Market display differences of *S. zeylanica* found in a wet market (a) and supermarket (b).

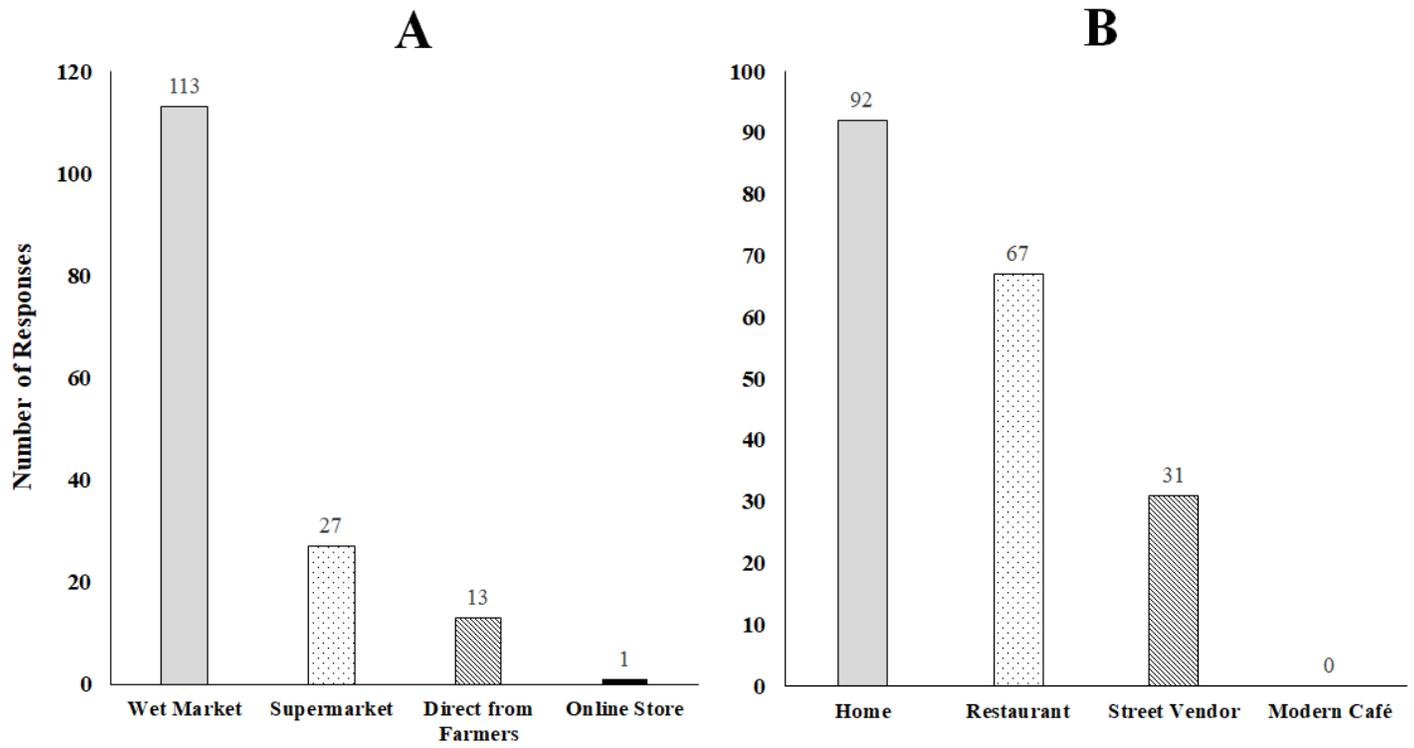


0 1.25 2.5 5 km



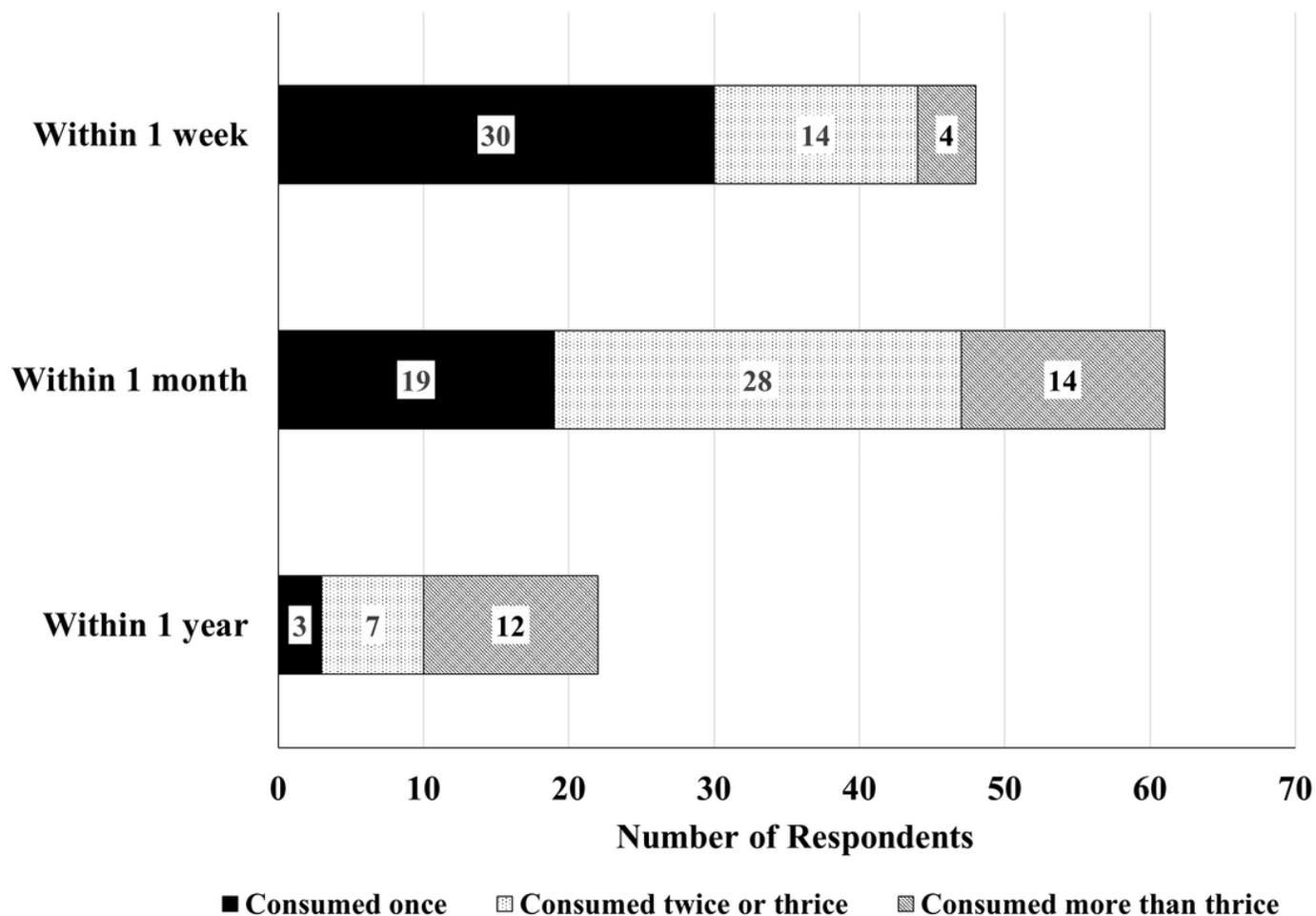
**Figure 5**

Distribution map of *S. zeylanica* purchase locations in Denpasar City. Shapes represent restaurants (red circle), wet markets (blue rectangle), and supermarkets (green triangle). Supermarkets where *S. zeylanica* was not available (black triangle) are also shown.



**Figure 6**

Ratio of purchase locations for fresh (A) and cooked or prepared (B) *S. zeylanica*.



**Figure 7**

Frequency of *S. zeylanica* consumption within different time periods in 2018–2019.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table1SzeylanicaAvailability.xlsx](#)