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Species Richness of Yapen Island for Sustainable Living Benefit in Papua, Indonesia

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Species Richness of Yapen Island: Exploring Plant Sources for Sustainable Living Benefit in Papua, Indonesia

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Running title: Species richness of Yapen Island

Abstract

The objective of this study was to precisely identify the types of utilization of the forest resources in two local communities. All forest plants used were identified and classified based on their types and classes during data collection. Semi-structural interviews through questionnaires were undertaken to obtain daily information. The results showed that there were a total of 64 forest plant life forms and categories extracted for various reasons. Most of the subject forest plants were found in the surrounding lowland tropical forest, the dominant categories were monocotyledons followed by dicotyledons, pteridophytes, and thallophytes. A strong positive correlation was determined between how frequently a species was used and the benefit value that was gained (0.6453), while a strong negative correlation

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Key words: Species richness, tropical forest, local communities, forest plant, edible plant

INTRODUCTION

Papua Island is the largest land mass in the Indonesian archipelago with a total area of 416,129 km^2 that constitutes millions of living organisms. Several natural resources are still in pristine condition and these lands are abundantly covered by thousands of plant types. The island has the potential to support all living activities preserve one of the oldest tropical forests in Asia and the Pacific (Takeuchi et al., 2013, Lekitoo et al., 2017). The fact that native people and tribes have benefited from the forest and environment over many generations is the key element on how the forest's support for living is tangible (Klute 2008). More than 200 tribes and traditional communities live in Papua, and most of them continue to depend on the forest. This is in the portrait of current living in interdependency with forests (Cabuy et al., 2012).

The support of the forest for relentless use of plant sources is fundamentally important, not only for balancing the natural ecosystem, but more importantly, it has been sustainably providing multi-benefit incomes in social aspects of people's lives. People who live and frequently interact with forest have mostly benefited during their lifetime (Ros-Tonen et al., 2003, Mukul, 2016). Multiple commodities were provided from the surrounding forest: staple foods, complementary foods and beverages, medicine, housing construction materials, clothes, and other daily components of the local lifestyle. This phenomenon occurred due to a legacy of traditional belief in which forests and the whole set of natural components are a fundamental heritage from ancestors and should be preserved and managed

in appropriate and sustainable ways (Wollenberg, Ingles, 1998, Morsello, 2012). However, the extraction of forest commodities in Papua is varied and depends on a tribe's background, living area, geographical status, etc. Such different circumstances lead to different forest utilization patterns among tribes and forest communities, as well as their future perspectives towards the long-term benefits of forests in Papua.

Therefore, the objective of this study was to identify forest plants intended for main and complementary components of living in Natabui and Papuma villages of Yapen Island in Indonesian New Guinea. For clarity, forest plant terms used in this study describes all plant species belonging to vascular and non-vascular plants, plant life forms and plant categories which were found during the field study. The study result will eventually provide a better understanding of forest plant distribution and how those plants contributed to living in traditional communities in Indonesian New Guinea.

MATERIALS AND METHODS

Study Area

The study area was situated in the low land tropical forest of Yapen Island in Indonesia New Guinea which lies between -2°2,4'8,424" and -1°23,4'19,548" South latitude, and between 134°56'21,708" and 137°4,2'20,592" East longitude (BPS, 2018). Two villages, namely Papuma and Natabui were chosen to conduct this study with a duration of 2 months during the summer of 2011.

Methods

Sample methods

The descriptive method through deep-interview and discussion was used in this study. Both deep-interview and discussion are based on semi-structural questionnaires. In detail, there were four key questions: 1) how often local communities interact with the surrounding forests and plant resources? 2) what is the benefit of the plant resources from the forest? 3) how

difficult is it to harvest the plant resource? and 4) what is the future prospect of the availability of plant resources, based on traditional perspectives in both villages? All data collected during the interviews and discussions were used to generate a trend of interaction in both villages.

Respondent preference

To obtain questionnaires data, respondents were selected based on the frequency of interaction with the surrounding forest and their socio-cultural role in the community. We decided to choose 20 % from the total population of both villages. Sampling is quite effective when dealing with a large ethnobotany study (Tongco, 2007). Therefore, a total of 70 people (n = 70) (20 % of the total population) were chosen to be respondents from both villages. These participants were then classified as village's leaders (10), religious leaders (4), or as zestfully active and inactive gardeners (56) who have experience with the plant resources.

Data collection

All data were recorded and converted to a quantitative system through a scoring from 0 to 10 based on the study by Sandelowski et al. (2009). Some modifications to the scoring system were made in this study for a better representation of the data (Whitehead et al., 2012). For the frequent use aspect, 0 represented less use and 10 represented the highest consumption of forest plants; for the aspect of benefit contribution of various plant sources, 0 indicated less benefit and 10 indicated the most benefit; for the aspect of difficulty of access, 0 was the most difficult and 10 was the easiest of collecting plant sources; for the future prediction scenario of plant source availability, 0 indicated the highest threat and 10 indicated the least threatened of forest plants.

Data Analysis

To quantify the distribution of forest plant life forms based on the growing habitat, a simple histogram was prepared. For the frequent plant uses based on plant life forms and plant

categories in distributions, the Kruskal Wallis test was applied using dplyr and ggpubr packages. In addition to understanding the correlation among frequency, benefit, access, and sustainability of use of forest plants in both villages, a correlation analysis was calculated and performed using corrplot package. All data were calculated using R statistical program 3.5.1. (R Development Core Team, 2018).

RESULTS

Local people in both villages extracted 64 types of forest plants from 33 families. In terms of plant life form, these consisted of 8 palm species, 14 perennial herb species, 4 climbing herb species, 2 liana species, 17 tree species, 4 bamboo species, 4 fern species, 3 shrub species, and 8 mushroom species. In addition to the plant category, these were classified as 36 monocotyledon species, 16 dicotyledon species, 4 pteridophyte species, and 8 thallophyte species. Most of these plants were consumed daily as food consumption, handfuls were used for traditional medicine, housing construction, and as food complements.

It was obvious that monocotyledon species were preferable to dicotyledon species for both villagers. In Natabui village, there were a total of 36 species from 17 families that came from the monocotyledon class. Next, dicotyledon use totaled 16 species from 13 families, and thallophytes and pteridophytes were the least consumed with only 12 species from 6 families.

In terms of geographical plant distribution and preference, most consumed plants were taken from the low land forest areas (<400 masl). For the preference of plant life form consumed, trees became were the most numerous consumed with a total of 17 species. The consumption of tree materials was followed by perennial herbs finally, lianas with only two species (Fig. 1). For the plant category, monocotyledon was the dominant form of consumable (36 species) compared to dicotyledons (16 species), pteridophytes (4 species), and thallophytes (8 species) (Fig. 2). From a total of 64 species of consumed plants, leaf parts were preferred with 28 species. The second most frequently consumed plant portion was the

126 fruit with about 19 species and the third was sprout emanating from five species, and other
127 minor portions were seeds and piths.
128 To understand the broader scope of intent, benefits gained from various forest species,
129 difficulty of access, and prospects for the future availability, generated a Spearman
130 correlation among these variables based on scoring data set obtained from community
131 respondents. A strong positive correlation (0.6453) was indicated between frequency of use
132 and benefit value gained for most respondents in both villages, while a strong negative
133 correlation was observed between benefit value and accessibility of certain species (-0.2646).
134 In addition, a strong negative correlation was noticed between frequency of use and the future
135 prospect of forest species availability (- 0.1405) (Fig. 4).

136 **DISCUSSION**

137 Plant resources represent substantial benefits and play a pivotal role in the existence
138 of local communities in both Papuma and Natabui village in Yapen Island. High interest of
139 local villagers in plants for food and other daily necessities gathered from the surrounding
140 forests indicated a significant dependency on the forest itself (Thomas, 1996, Ticktin, 2004,
141 Shanley et al., 2008). In fact, this dependence has been driven by local necessities that
142 unequivocally need to be fulfilled on a day-to-day basis, such as staple and complement
143 foods for feeding family members and traditional medicine to cure wounds and other health
144 problems occurring in the community (Rasingam, 2012, Hanh et al., 2018, Nero et al., 2018).
145 Foods that are available from the forest were preferred due to ease of access and the fact that
146 they are free for the taking, available every day, and quite diverse and abundant. Considering
147 the predominantly low economic income of the villagers, their willingness to favor free
148 natural foods available around them rather than spend money to purchase from other sources
149 is understandable. In addition, ease of access was a preferred alternative for most villagers
150 since those natural food sources were literally growing in their land and diverse in number.

Omkar et al. (2012) pointed out that easily accessible forest resources raise the likelihood of extracting numerous forest resources for daily consumption in tropical dry deciduous forests in India. Neumann and Hirsch (Neumann, Hirsch, 2000) described a household nearby the resource will have a higher intensity of accessing and interacting with the surrounding forest than those a bit far away.

In terms of landscape preference for harvesting, it was obvious that the local communities were more likely to yield various plant resources in the lowland forest (<600 masl) which generally tends to be a relatively even landscape with a slope less than 20°. Ecologically more dominant plant life forms and categories, in particular palm, perennial herb, climbing herb, grass, and several other monocotyledon were spread below 700 masl (Whitmore, 1998, Huang et al., 2003). Keppel et al. (2005) found as many as 560 indigenous species of vascular plants (52 % endemic) in the low land tropical rain forest of Viti Levu, Fiji. In addition, a high number of soil nutrients in the lowland forest of Yapen Island was observed, with a high amount of substrate also abundantly found in the two lowland forest areas, presumably indicating a potential regeneration of plant growth compared to that in the higher land (Ostertag et al., 2014). Sago palm as the most preferred staple food for locals was growing along the river, low-land swamp forest and peat land. These areas have been rich in soil nutrients and substrate which contributed toward sago starch productivity (Lina et al., 2010, Novero 2012, Ehara et al., 2018). Sim, Ahmed, (1991) noticed a stunning production of sago starch in Sarawak, Malaysia ranging between 88 and 179 kg found in the peat soil and mineral soils, approximately ranging between 123 and 189 kg. Several edible palms were growing along the riverside and lowland areas in both villages as these areas were characterized by an ideal temperature (Eiserhardt et al., 2011, Elias et al., 2019).

On a daily basis, the most frequent plant category being consumed in both villages was monocotyledons, followed by dicotyledons, thallophytes, and pteridophytes. The

tendency to choose monocotyledons was driven by their wider distribution and growth dominance in the lowland forest and landscape. Bognounou et al. (2011) highlighted that monocotyledons were more diverse and higher in density than dicotyledons in both primary and secondary forests of Corcovado National Park in Costa Rica. Apart from these, several plants have been pivotal for daily consumption and function as staple food and essential vegetables. Meanwhile, dicotyledons have been prioritized solely for wood consumption and housing construction. However, a small portion was preferred as food. Thallophytes and pteridophytes contribute as additional nutrients and improve daily diets. Rasingam and Parthasarathy (Rasingam, Parthasarathy, 2008) revealed that herbs, shrubs, and grasses have been dominant species growing densely in the lowland forest in Little Andaman Island, India. However, dominance of monocotyledon species can be a glaring indication of ecological degradation in the ecosystem (Granville, 1984).

In general, trees have been preferred for fulfilling local needs compared to other types of forest plants for inhabitants of both villages. The basic rationale was that a whole tree could provide multiple benefits ranging from wood for construction, wood for fire, shoes/clothing, home furnishing, and daily diet for local inhabitants (Michon, 2005, Powell et al., 2013). Hlaing et al. (2017) defined timber as the most frequently gathered material (96%) from the forest compared to other sources among rural forest communities in the Katha district of Myanmar. In addition, the dominant forest cover in both forest areas was made up of vascular trees with a moderate density of tree distribution. In addition, perennial herbs, palms, and mushrooms have been an alternative in fulfillment of daily necessities. Perennial herbs possess multiple benefits, such as food for carbohydrate and vitamin sources and the use of stem, leaves and barks for medicinal purpose, which the locals take advantage of (Sunderland, Ndoye, 2004, Tölgyesi et al., 2018). Palms and mushrooms also render numerous benefits for local inhabitants. A primary component from palm (sago) is starch as a

carbohydrate source, while its bark and leaves can be converted to housing components such as flooring and roofing. Mushrooms can be consumed on a daily basis as a vitamin source and a medicinal component for healing several common diseases occurring in those villages (Wasser, 2002). In terms of plant parts being used, leaves were preferred for fulfilling local inhabitants' necessities followed by fruits, sprouts, and other parts. Leaves render multiple uses such as sources of vitamins in the form of vegetables, sources of medicine, and use in housing and various home accessories. Sunderland et al. (2002) specified edible leaves' contribution approximately 23.3% and for housing thatch at approximately of 0.7% towards cash income for local communities around Takamanda Forest Reserve of Cameroon. Kamga et al. (2013) noted a high intensity of leaves consumed on the household scale which was more than once a week in Yaounde, southern Cameroon. Concerning the consumption pattern, 13 species (20.4%) of forest plants could be directly consumed and 51 species (79.6%) were processed through cooking methods. The predominance of indirect uses means local communities prefer variation towards final products of edible plants. By cooking, the taste, shape and nutrient components will be different. Most of indirect edible products were produced using the leaves and starch (FAO, 2011, Nowak, 2017). Frequent directly consumed parts of forest plants were sprouts emanating from several palms, perennial herbs, trees species, and young leaves (Márton et al., 2010, Maroyi, 2014).

The more frequent the interactions with surrounding forests, the more benefit value will be raised or linearly correlated for most local communities. This underlies the fact that more interactions with the forest will render more foods that are edible and other complementary goods. Colfer et al. (2006) found that a good diet needs food availability and can often be a result of interaction with the forest. In terms of economic income, use of basic forest plants can be a source of money, which can be put toward the improvement of local households' life (Neumann, Hirsch, 2000, Eastin et al., 2001). Vinceti et al. (2013) indicated

the importance of edible forest foods obtained overtime because it consistently fulfilled locals' necessities rather than solely in a particular period. On the contrary, high frequency of forest access and plant consumption eventually will attenuate the overall potency of forest biodiversity and edible resources in both villages (-0.1405). Therefore, a potential alternative of better forest resource management such as community forest will increase the future prospect of forest sustainability (Dhakal et al., 2016). Mitchell et al. (2003) pointed out the negative effect on the ecological landscape and natural regeneration of flowering in high amounts of nut and fruits extraction is undertaken overtime.

CONCLUSION

The distribution of forest plants that are consumed was assessed by evaluating species contribution toward local living benefit in two villages, Papuma and Natabui. Semi-structural interviews were carried out to determine how intense the collection was, what the value of the benefits from the plant resources was, the accessibility of the plants, and the prospects for the future sustainability of the surrounding forest plants for inhabitants in both villages. The results indicate various life forms and categories of forest plants have significant contributions particularly in daily food supply for diet. Spearman correlation indicated a strong positive correlation between how frequent the interaction and value of the benefit gained from surrounding forest, where a strong negative correlation was shown regarding the correlation between accessibility of forest plants and value of the benefit gained.

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FIGURE

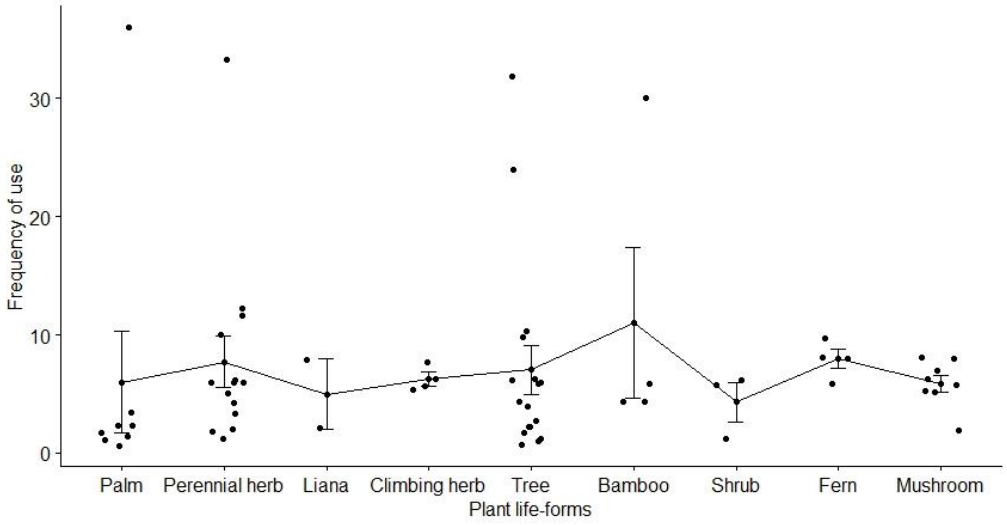
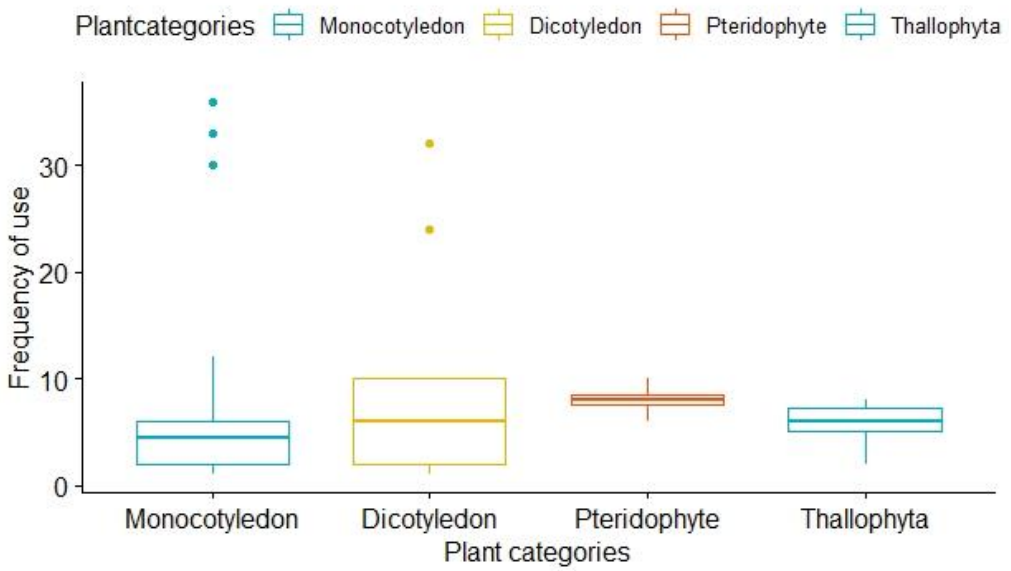


Fig. 1. The relationship between plant life form distributions and frequency of use from all plant species consumed in Papuma and Natabui villages. Kruskal Wallis test noted that there is no significant difference in use between plant life forms and use which is indicated by p-value of 0.219 (> 0.05 of significance level).



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412 **Fig. 2.** Relationship between plant categories (monocotyledon, dicotyledon, pteridophyte, and
413 thallophyte) and frequency of use intended for consumption in Papuma and Natabui
414 villages. Kruskal Wallis test designated no significant difference as indicated by p-value
415 of 0.208 (> 0.05 of significance level).

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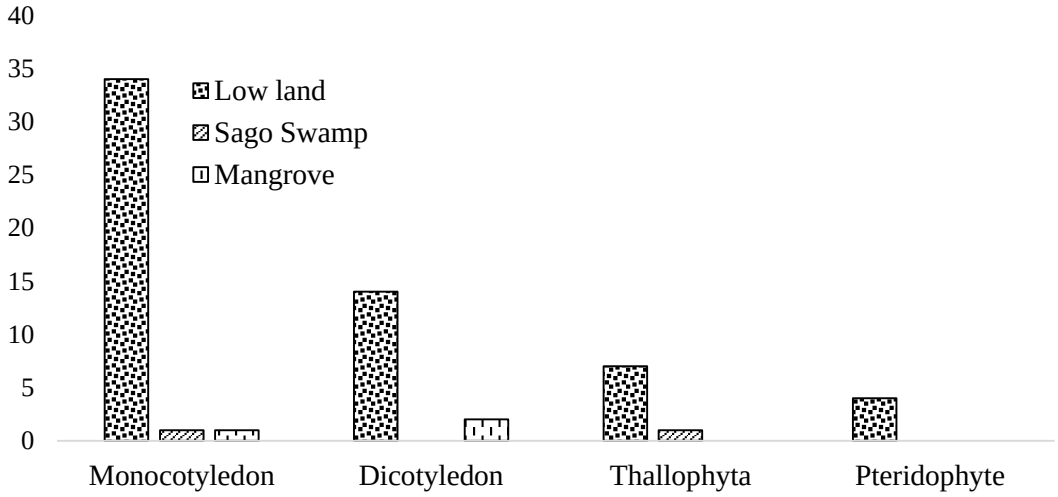

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420 **Fig. 3.** Histogram highlighting the distribution of plant sources based on categories and
421 growing habitat in Papuma and Natabui villages of the Yapen Island.

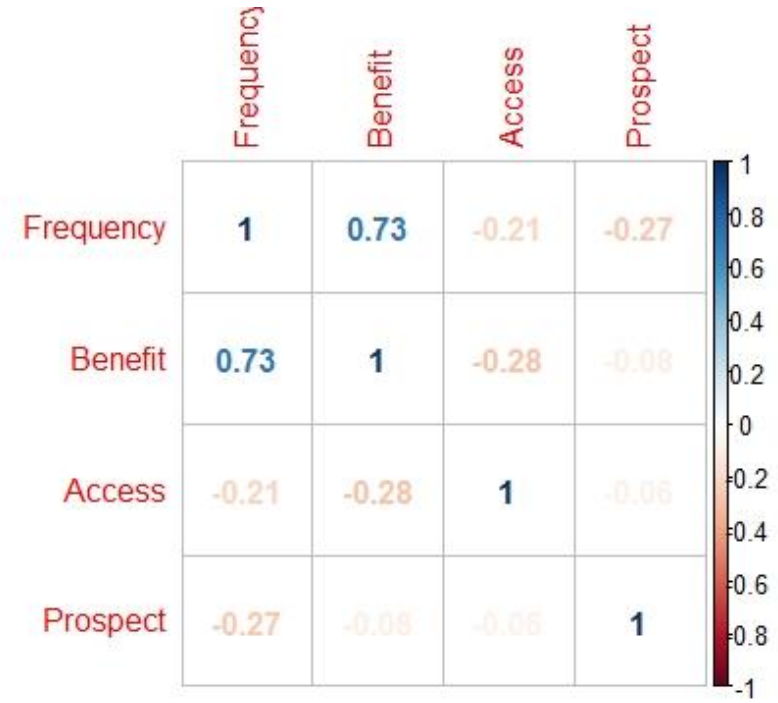

Fig. 4. Multiple correlations indicating relationships among frequency of use, benefit value, access, and sustainability of forest resources in both villages based on scoring list data ranging from 1 to 10 gathered from respondents. Dark blue color (top bar scale) indicated very positive significant correlation, whereas the dark red color (bottom bar scale) indicated very negative significant correlation from variables.

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SPECIES RICHNESS OF YAPEN ISLAND : EXPLORING PLANT SOURCES FOR SUSTAINABLE LIVING BENEFIT IN PAPUA, INDONESIA

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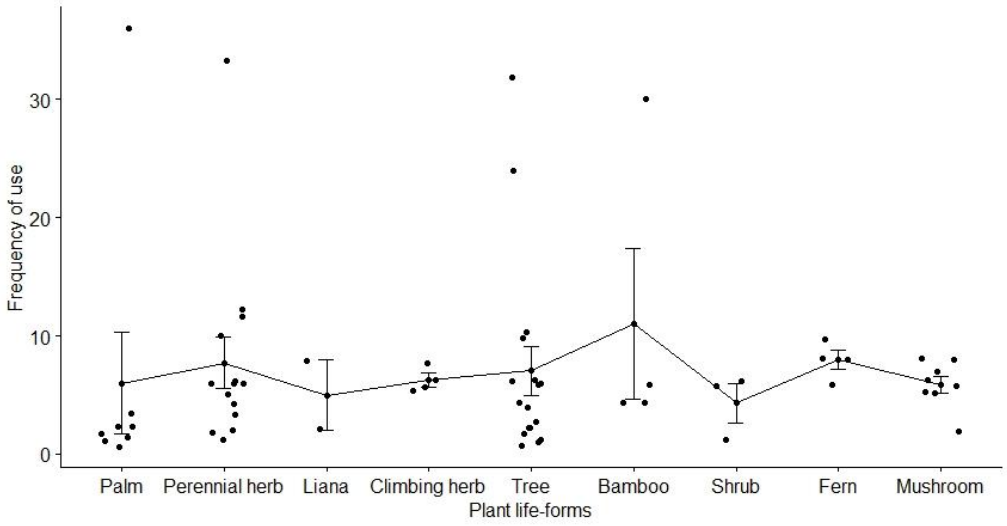


Fig. 1. The relationship between plant life form distributions and frequency of use from all plant species consumed in Papuma and Natabui villages. Kruskal Wallis test noted that there is no significant difference in use between plant life forms and use which is indicated by p-value of 0.219 (> 0.05 of significance level).

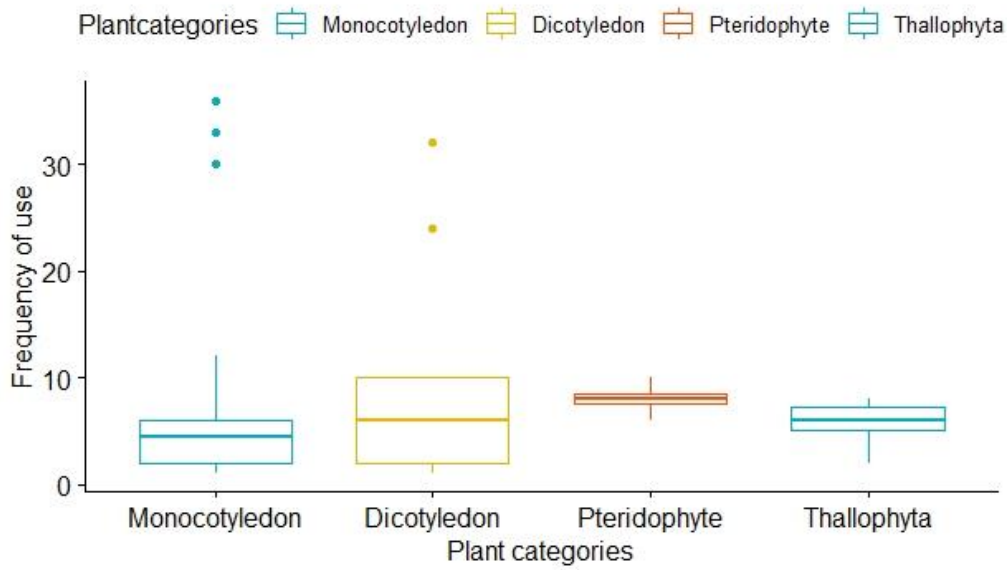
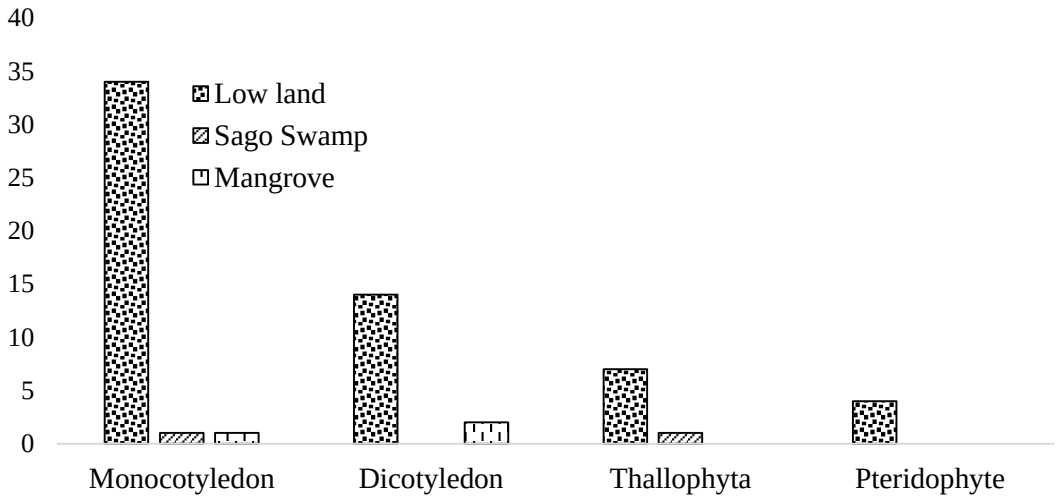


Fig. 2. Relationship between plant categories (monocotyledon, dicotyledon, pteridophyte, and thallophyte) and frequency of use intended for consumption in Papuma and Natabui villages. Kruskal Wallis test designated no significant difference as indicated by p-value of 0.208 (> 0.05 of significance level).



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