CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

Ethnobotany of Wild Edible Plants in Huu Lien Nature Reserve, Vietnam

MASTER'S THESIS

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Author: Bc. Eva Križanová

Supervisor: doc. Ing. Zbyněk Polesný, Ph.D.

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DIPLOMA THESIS ASSIGNMENT

Bc. Eva Križanová

Tropical Crop Management and Ecology

Thesis title

Ethnobotany of wild edible plants in Huu Lien Nature Reserve, Vietnam

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Objectives of thesis

The Huu Lien Nature Reserve, located in Lang Son province, northern Vietnam, is endowed with high biodiversity while being one of the poorest regions with strong dependence on forest resources. The aim of the thesis is to document the diversity and use of the plant resources with focus on wild food plants used among local communities. To understand and preserve the traditional ethnobotanical knowledge, eventual variations among local ethnicities will be evaluated and taken into account. Considering a growing market demand for wild plants in Vietnam, this study could identify species commercialized and potential conservation issues.

Methodology

Two distinct localities will be investigated: communities within Huu Lien Nature Reserve (HLNR), and Yen Thinh commune in the buffer zone of HLNR. The relevant ethnobotanical data will be obtained by using a combination of several methods. Randomly chosen participants will be interviewed using semi-structured questionnaires. Information on species local name, plant life form, plant part used, techniques of collection and purpose of use will be noted. Additionally, direct observation and 'walk in the wood' approach (Martin, 1995) will be applied. Species gathered together with informants will be sampled, in order to prepare herbarium reference collection, and taxonomically identified. The collected data will be analyzed using combination of the qualitative as well as quantitative ethnobotanical methods.

The proposed extent of the thesis

50 pages

Keywords

ethnobiology, food plants, forest products, protected area, Vietnam

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Recommended information sources

Ashagre, M., Asfaw, Z. and Kelbessa, E. (2016). Ethnobotanical study of wild edible plants in Burji District, Segan Area Zone of Southern Nations, Nationalities and Peoples Region (SNNPR), Ethiopia. Journal of Ethnobiology and Ethnomedicine, 12(1).

Cruz-Garcia, G. and Price, L. (2011). Ethnobotanical investigation of 'wild' food plants used by rice farmers in Kalasin, Northeast Thailand. Journal of Ethnobiology and Ethnomedicine, 7(1), p.33.

Martin, G. (1995). Ethnobotany: A methods manual. London: Chapman & Hall.

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The Diploma Thesis Supervisor

doc. Ing. Zbyněk Polesný, Ph.D.

Supervising department

Department of Crop Sciences and Agroforestry

Electronic approval: 8. 3. 2018

doc. Ing. Bohdan Lojka, Ph.D.

Head of department

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doc. Ing. Jan Banout, Ph.D.

Dean

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Declaration

I hereby declare that I have done this thesis entitled "Ethnobotany of Wild Edible Plants in Huu Lien Nature Reserve, Vietnam" independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague April 26, 2019

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Eva Križanová

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Abstract

The Huu Lien Nature Reserve is located in a high biodiversity karst zone in Northeast Vietnam. It is one of the poorest regions with a strong dependence on forest resources that are particularly valuable for ethnic minorities. This ethnobotanical study aims to document the diversity and use of plant resources with a focus on wild food plants, to assess the distribution of the local traditional knowledge and to preserve it. Randomly chosen participants were interviewed using free-listing and semi-structured interviews in July 2017. Local name, edible part, mode of plant preparation, plant life form, season and additional use were recorded. Quantitative indices as Relative Frequency of Citation, Smith's Salience Index and Cultural Value were calculated to analyse the cultural importance of recorded species. A total of 58 ethnospecies belonging into 42 genera and 35 families were described as edible. Edible parts were mostly fruits (72%) and thus mostly consumed unprocessed. The culturally most important species were *Melientha suavis* (Opiliaceae), *Xerospermum noronhianum* (Sapindaceae) and *Camellia* sp. (Theaceae). Wild plants were reported to be consumed as snacks, vegetables, beverages or utilized as flavourings or preserves. Additionally, the nutrient composition of the priority species was reviewed, and several local species were identified as good sources of the most important micronutrients connected to malnutrition in Vietnam.

Documentation of these useful species will preserve the local traditional knowledge, provide basic information for conservation and possibly for further exploitation to help the local communities.

Keywords: traditional knowledge, biodiversity, wild edible plants, Vietnam, nutrition

Table of Contents

List of Tables

List of Figures

List of the abbreviations used in the thesis

CIA	Central Intelligence Agency
CR	Critically Endangered – IUCN Red List category
EN	Endangered - IUCN Red List category
FAO	Food and Agriculture Organization of the United Nations
FC	Frequency of Citation
GSO-WB	General Statistics Office and the World Bank
IUCN	International Union for Conservation of Nature
NIN	National Institute of Nutrition
NTFP	Non-timber forest products
PROSEA	Plant Resources of South East Asia
RFC	Relative Frequency of Citations
SS	Smith's Salience Index
UNEP-WCMC	United Nations Conservation Programme - World Monitoring Centre
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
UR	Use Report
VU	Vulnerable - IUCN Red List category
WEPs	Wild edible plants
WWF	World Wide Fund for Nature

1. Introduction

1.1. Study area

Vietnam occupies the area of 330 957.6 km^2 in the eastern part of the Indochinese peninsula in Southeast Asia. The country's narrow shape extends 1,650 km north to south, while it is only 50 km wide across at its narrowest point. It borders Lao, China and Cambodia. In 2018 the Vietnamese population was estimated to more than 97 million people of 54 ethnic groups that have been recognized by the Vietnamese Government. Kinh ethnic group is the majority, occupying nearly 90% of the whole population (CIA 2018).

Vietnam, officially the Socialist Republic of Viet Nam, is since the end of the Vietnam war a communist state. After the political and economic reforms (Đổi Mới Policy) in 1986, Vietnam has transformed from one of the poorest nations in the world to now a middle-income country with ambitious goals of becoming a developed country until 2020.

Vietnam has one of the highest population densities, but the population is dispersed unevenly. An estimated 70% of Vietnam's population lives in low-lying areas in the Mekong River Delta, in the Red River Valley and in the coastal areas, while 36% of the population is living in urban areas (GFDRR 2015; CIA 2018).

The survey site of this study, Huu Lien Nature Reserve (HLNR), lies in Huu Lung District in Lạng Sơn Province. Lạng Sơn is a frontier mountainous province located in the Northeast region (Đông Bắc Bộ) of Vietnam, bordering Guangxi province of People's Republic of China (see Figure 1). It is a rural area, approximately 130 km from Vietnam capital Ha Noi, 21°37' - 21°45' of northern latitude and 106°19' - 106°26' of eastern longitude.

Lạng Sơn province is culturally and naturally rich region, with human history dating to Pleistocene (Olsen & Ciochon 1990). However, economically, it is one of the poorest regions in Vietnam. The Vietnam's rapid growth helped to reduce the poverty rate from 58% (first survey in 1993 by GSO-WB) to 13.5% in 2014 (UNDP 2018), but it was

unfortunately not reflected in ethnic minorities and rural populations. Rural areas account for 95% of Vietnam's poor. The economically secure or middle class are only 23 per cent of ethnic minorities (compared to 82% Kinh and Hoa), and 44% people of Midlands and Northern Mountains (including Lạng Sơn province; Pimhidzai 2018).

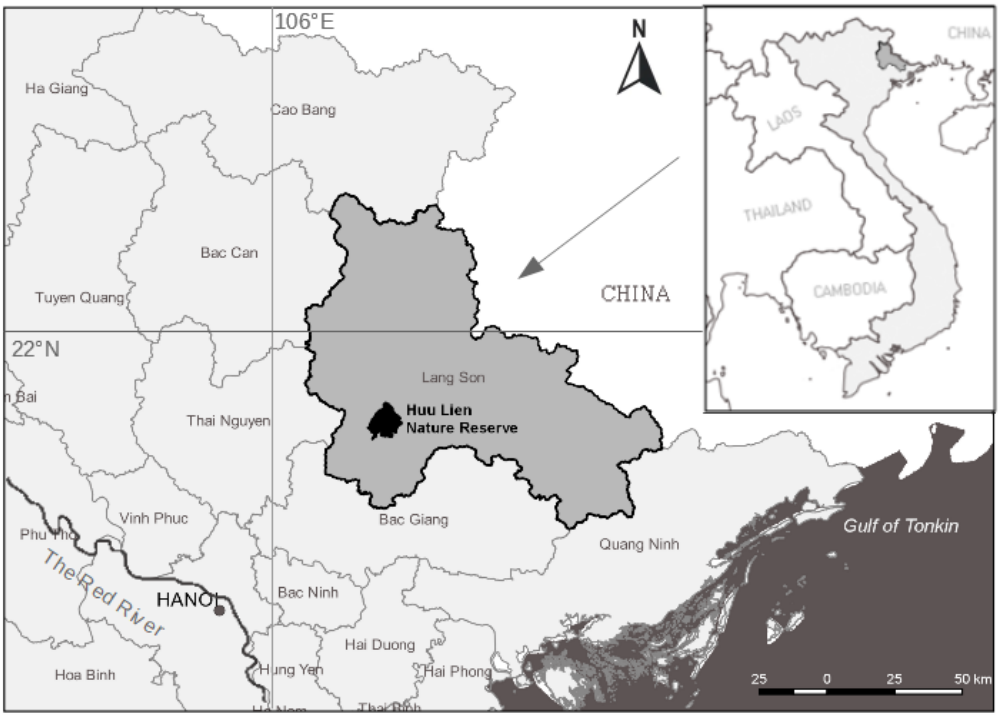

Figure 1. Localization of Huu Lien Nature Reserve

1.1.1. Huu Lien Nature Reserve (HLNR)

Huu Lien Nature reserve is one of the smaller protected areas, covering 10640 ha. It was founded in 1992 to protect the unique ecosystem of forests on limestone and Musk deer (*Moschus berezovskii*), globally endangered and listed on Appendix II of CITES, known only from two localities in the period of reserve foundation (CITES 2017; Wang & Harris 2015).

The latest available survey reported 3183 inhabitants belonging to four ethnic groups: Kinh (68%), Dao (13%), Tay (11%), Nung (8%) (Furey et al. 2002, Brinkhoff 2009). Settlements are concentrated in the middle, flat area, along the main road. A local Commune People's Committee (*Ủy Ban Nhân Dân Xã Hữu Liên*), a facility for rangers taking care of the Nature Reserve, a primary and a middle school could be found within HLNR.

Local livelihoods come mostly from agriculture, paddy rice, maize and cassava being predominant crops. Furey et al. (2002) noted two crops of paddy rice per year were allowed by the construction of a dam, but still periods of food shortages were reported during months 3-4 and 8 of the Vietnamese lunar calendar. In 2017 a small market with local produce was taking part in HLNR once a week.

Yen Thinh is the closest settlement from HLNR, only approximately 5 km from its southern border. Previously described as part of HLNR or its buffer zone.
The schematic map of HLNR could be seen in Figure 2.

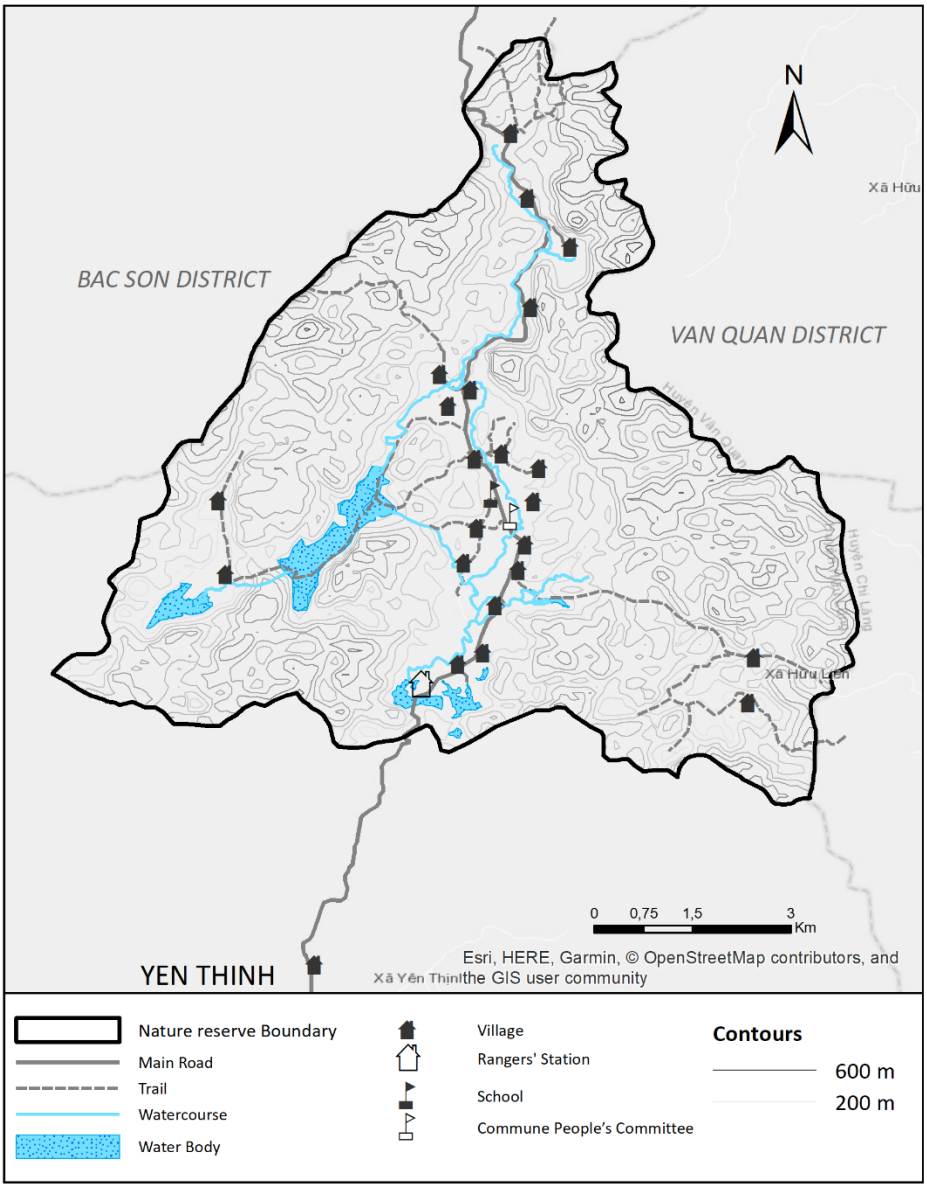

Figure 2. Map of HLNR showing key features

1.1.2. Environmental conditions of the study area

Vietnam is strongly influenced by north-easterly monsoons and the average temperature is lower than that of other countries of the same latitudes in Asia. In the southern provinces, the temperature is higher, and the climate is more stable than in the northern provinces where the climate changes noticeably during the four seasons.

According to updated Köppen-Geiger classification, the climate in Lạng Sơn province is humid subtropical (Cwa), characterized by hot and humid summers and mild winters with much less rainfall than in summer (Kottek et al. 2006).

In HLNR, the annual average temperature is between 21-24°C. The hottest month is July (>28°C) and January is the coldest (15°C). In a year, the average rainfall is 1488 mm. The wet season is from April to October when the great majority of precipitation falls (Furey et al. 2002). The climate diagram of Lạng Sơn province is shown in the Figure 3.

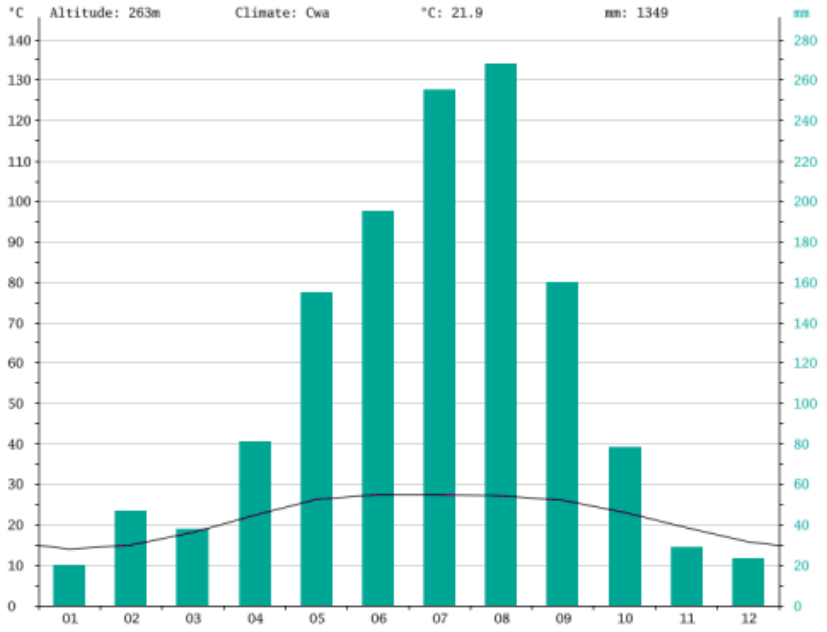

Figure 3. Climate diagram of Lạng Sơn province. Adopted from CLIMATE-DATA.ORG 2018.

Most of the nature reserve is mountainous (300 - 500 m a.s.l.), with two flat valleys running through in north-south direction at 100 m elevation. The highest peak is Mount Kheng at 638 m above sea level. Local soils are complex patterns of substrates ranging from bare rock or talus and scree on outcrops to thick soil layers in valley floors (Furey et al. 2002). There are several streams and lakes used as a water source for people and

rice fields. Strong seasonal fluctuations cause great enlarging of the lakes and flooding during the wet season.

1.1.3. Tropical karst

The northeastern region of Vietnam, along with western Guangxi, southern Kweichow and eastern Yunnan Provinces of China are part of the South China Platform that structurally differs from the southern parts of South East Asia. The majority (91%) of the land in the Reserve is composed of limestone of marine origin deposited in late Paleozoic and early Triassic (Averyanov et al. 2003). Thick sequences of carbonate rocks, mostly limestone, are widespread both inland and offshore in northern and central Vietnam (Dang et al. 2009), as the total area of karst exposures covers around 18% of the country (Krobicki et al. 2006). HLNR is part of Việt Bắc karst zone and it is the largest limestone region out of total five found in Vietnam (Lunde et al. 2007).

The unique landscape of HLNR is strongly defined by its characteristic topography with limestone outcrops of tower karst. Karst landscapes are often stunning and attractive to tourists. Some world class karst terranes can be found in northern Vietnam, the famous Hạ Long Bay is located in relative vicinity to HLNR. It is a UNESCO World Heritage Site for its outstanding aesthetic, geological and geomorphological value that attracts thousands of tourists every year (World Heritage Committee 1994).

In HLNR, the steep hills contrast with flat narrow valleys predominated by red iron-rich or brown mudstones. These unique structures have been formed by weathering processes during the late Cenozoic period in the context of tropical weather condition (Dang et al. 2009). Nowadays, these flat areas are used as residential and for agriculture. The karst directly controls the distribution of the flora, fauna, vegetation cover and ecosystem in general. Particular water and soil conditions (little standing or running water, alkaline environment, low general fertility, thin layers of topsoil, thicker in valleys) and unique terrain (caves, underground streams, sinkholes, sheer cliffs) of tropical karst ecosystems create suitable conditions for very rich biodiversity. A high degree of endemism is also common (Tuyet 2001).

However, available information on biodiversity could be severely underestimated as karsts are in general understudied. Many new or/and endemic species of flora and fauna have been discovered each year (Grismer et al. 2014; Pauwels & Sumontha 2014; Grismer et al. 2016; Averyanov et al. 2018; Kumar et al. 2018; Kidyoo 2018; Poyarkov et al. 2018; Sang et al. 2018; Chen et al. 2019) and the unexplored limestone regions in Southeast Asia have high potential for the discovery of numerous new (and endemic) species.

Despite these ecosystems being unique, valuable and rich, they are threatened by anthropogenic disturbances in many places of Southeast Asia, quarrying for cement production being the biggest risk. Rapid economic growth creates a high demand for these products and is also highly profitable (Clements et al. 2006). An estimation by Day and Urich (2000) was that probably only less than 10% of the karst in SE Asia retains its natural vegetation. Regional protected areas and conservation legislation is highly variable in nature and effectiveness. The protection of designated areas is problematic in practice. In 2006 between zero to 44% of karst areas were protected in the individual countries of Southeast Asia (Clements et al. 2006).

1.1.4. Natural biodiversity and conservation situation

Vietnam itself is a country of exceptionally high biodiversity, containing many rare and endemic species, particularly in the forest ecosystems. It is located within Indo-Burman biodiversity hotspot, ranking 16th most biodiverse country in the world (Quieroz et al. 2013). The number of vascular plants is estimated up to 12 000 species in more than 2500 genera, while around 10% of species being endemic (Vo Quy 1995; Averyanov et al. 2003).

Biodiversity surveys in HLNR documented 1093 plant species belonging to 598 genera and 149 families (Chu & Nguyen 2015). Concerning local fauna, surveys up to present recorded 168 bird species, 21 amphibian, 10 lizard and 44 species of terrestrial mollusks, 181 butterfly species, including previously unknown species (Nguyen et al. 1999; Furey et al, 2002; Lunde et al. 2007; Nguyen et al. 2011; Đỗ Văn Nhượng et al.

2017). Up to 75 mammal species had been documented since first surveys 1990's, including 21 bat species and rodents (Can et al. 2000; Lunde et al. 2007), and the Chinese Forest Musk Deer (*Moschus berezovskii*) that is considered endangered and extremely rare in Vietnam (Wang & Harris 2015). It seems that several key species, including the Western Black-crested Gibbon (*Nomascus concolor*), may have already become locally extinct at the period of the foundation of the Reserve (Furey et al. 2002).

During survey in 1999, 31 species of local flora listed in the Red Data Book of Vietnam were identified (Nguyen et al. 1999), such as critically endangered *Cupressus tonkinensis, Burretiodendron tonkinensis* and *Garcinia fagraeoides*. While in 2015, already 55 plant species encountered are listed in Red Data Book of Vietnam (Nguyen 2007b; Chu & Nguyen 2015). Several of these species possess restricted distributions, currently only known from northern Vietnam and southern provinces of China (*Parashorea chinensis, Deutzianthus tonkinensis, Burretiodendron tonkinense*) and some are further confined to limestone areas (*Laportea urentissima, Cupressus torulosa;* Furey et al. 2002).

On the other hand, species new not only to HLNR and but also to science have been regularly discovered until present (Musser et al. 2006; Rösler et al. 2010; Ziegler & Nguyen 2010; Hämäläinen 2012; Averyanov et al. 2015; Peng et al. 2015; Zhang et al. 2015).

1.1.5. Vegetation of HLNR

Geobiologically, Huu Lien Nature Reserve is situated in the South China tropical area with North Vietnamese subtropical forests (Nguyen et al. 2011). According to WWF classification, HLNR belongs to South China-Vietnam evergreen forests ecoregion, with the natural climax vegetation being seasonal evergreen forest on limestone (Thai Van Trung 1987; Olson & Dinerstein 1998). Within the Nature Reserve, four principal vegetation communities may be recognized: (1) evergreen forest in valleys and soil-based hills, (2) evergreen forest on foot slopes of limestone outcrops, (3) stunted

vegetation types present at middle elevations and (4) on summits of karst outcrops (Anon 1991).

Most of the Reserve is still forested. However, this is only due to specific terrain composed of hills that are very steep and unsuitable for cultivation and difficult to access. Forest was cleared or highly degraded on basically all accessible flat areas and valley floors. Forest clearance and logging have led into the fragmentation of remnant areas, much of which is also disturbed, into two relatively isolated blocks on the east and west sides of the Reserve. The low areas are now used for settlements and agriculture, pasture for grazing animals or two primarily anthropogenic habitats, secondary scrub and secondary savannah, have developed in the fallow areas. Characteristic species of the latter habitats include *Helicteres* spp., *Mallotus paniculatus, Eupatorium odoratum, Imperata cylindrica* and *Miscanthus floridulus*, including members of the Fabaceae (*Mimosa* spp., *Crotalaria* spp. and *Desmodium* spp.) and Asteraceae family (*Ageratum conyzoides* and *Artemisia vulgaris;* Do et al. 2000).

In remaining forest areas two types of forest could be distinguished (Furey et al. 2002). The first type are forests on steeper, soil-based slopes with isolated rock outcrops. The dominant tree species are from Moraceae family (*Streblus* spp.), followed in a lesser extent by members of Sterculiaceae (*Sterculia* spp., *Pterospermum* spp.), Sapindaceae (*Nephelium* spp., *Sapindus* spp., *Pometia* spp.) and Ebenaceae (*Diospyros* spp.). Species from ground story belong typically to Zingiberaceae (*Curcuma* spp.), Vitaceae (*Vitis* spp.) or Arecaceae (*Caryota* spp.)

The second type, occurring on gentler slopes, is distinctive in abundance of *Parashore*a spp. (Dipterocarpaceae), and lack of several prominent families (Sterculiaceae, Sapindaceae). In contrast to the first type, the ground flora is composed of numerous herbaceous species and palms. Commonly found could be *Caryota* spp. and *Calamus* spp., from Arecaceae *Agaonema* spp*., Colocasia* spp. or *Amorphophallus* spp., and others such as *Melothria* spp. (Cucurbitaceae) or *Peperomia* spp. (Piperaceae). A special type of vegetation can be found upon the summits of isolated limestone outcrops. These support a stunted plant community which includes the endangered conifer species *Cupressus torulosa* (Cupressaceae).

2. Literature review

Since the ancient times of hunter-gatherers, prior to the development of agriculture, human societies relied on wild food plants as the main part of their meals. Nevertheless, the advancements in agriculture brought considerable changes to the human diet and a gradual abandonment of wild species, resulting in a significant reduction in dietary diversity. Nowadays, societies depend on a relatively small number of domesticated plant species. According to the Food and Agriculture Organization of the United Nations, around 7000 plant species have been utilized as a food source by humans (FAO 1998), but only 30 plant species provide more than 90% of the human nutrition (Hammer et al. 2003), while the number of edible plants is estimated to reach 30,000 species (Shaheen et al. 2017). The current focus on cultivated crops is connected to a decline of collective skills and knowledge of useful species. Despite the ongoing trends, wild edible plants are still consumed traditionally by numerous communities and are an important and valuable resource of food and knowledge in today's world.

While the wild food and medicinal plants are essential in Vietnamese cuisine and traditional medicine, the knowledge is disappearing and still has not been sufficiently documented. This work documents the importance, diversity and use of wild plants in the study area.

2.1. Definition of Wild Edible Plants (WEPs)

The term in this paper is used as defined by FAO, as "plant species that grow spontaneously in self-maintaining populations in natural or semi-natural ecosystems and can exist independently of direct human action" (Heywood 1999). They mostly include native species, but sometimes introduced species as well.

The term is in contrast with "cultivated" or "domesticated" plants that have been affected by human intervention and management. The distinction is often difficult to make, as it is a rich spectrum that can include wild species brought to home gardens and cultivated, remnants from former forest, transfers of wild plants near human

settlements or trails for easy availability etc. Therefore, these plants could grow and be sourced from various habitats.

Numerous are found in primary or secondary forests (e.g. *Aganonerion polymorphum, Gnetum gnemon, Garcinia oliveri, Bambusa variabilis, Spondias pinnata*), as well in other locations as uplands and along roads (e.g. *Oroxylum indicum, Gnaphalium luteo-album, Sesbania grandiflora*), water bodies (e.g. *Nelumbo nucifera, Nymphaea nouchali, Ludwigia adscendens*) and along banks of rivers and streams (e.g. *Uncaria acida, Stenochlaeana palustris, Horsfieldia irya*, *Garcinia schomburgkiana*), backyards (e.g. *Gynura crepidioides, Emilia sonchifolia, Talinum paniculatum*). Various popular herbs often grow in fields, paddy fields or fallow lands (e.g. *Commellina communis, Portulaca oleracea, Rorippa indica*) or ditches and drains (e.g. *Ipomoea aquatica*, *Limnocharis flava*, *Limnophila rugosa;* Tanaka & Nguyen 2007).

In the developed world the industrial revolution brought major changes to lifestyle and promoted underutilization of wild species. Large scale cultivation of monocultures and decreased availability of plants due to ecosystem changes, forgotten memories of famine or less contact with nature are the reasons according to Łuczaj et al. (2012) of the disappearance of WEPs use. However, after decades of abandonment of wild plants, their use has gained popularity again as "health foods", gastronomic fashion trends, *haute cuisine* or part of survival courses. The "rediscovered" knowledge and use are often different than the original local practices, sometimes also including new species that were not used before (Łuczaj et al. 2012; Schunko et al. 2015).

In contrast to the common view that the importance of wild food gathering is decreasing, there is strong evidence that wild food is still an important part of the diet in many communities in developing countries, insomuch that they contribute to the diet of at least one billion people (Burlingame 2000; Boedecker et al. 2014).

The main characteristics and advantages of WEPs use include (based on Shumsky et al. 2014):

- They are locally available, and their use is based on traditional ecological knowledge (Pardo-De-Santayana et al. 2005; Redzic 2006; Arenas & Scarpa

2007). This indigenous knowledge is a precious part of the cultural heritage of different regions of the world.

- They are a low-input, low-cost option for increasing nutrition (Shackleton & Shackleton 2004; Jama et al. 2008). Wild species are an important source of trace minerals, vitamins and health-beneficial compounds. In contrast to conventional, cultivated vegetables, wild food plants require less care and are typically less affected by pollution, like pesticides and insecticides.
- In some regions of the world, they continue to be a major source of nutrition for tribal people (Thakur et al. 2017) or serve as a supplementary food and provide cash income as well (Ju et al. 2013). Moreover, they provide greater benefits to vulnerable populations (poorer households, women, and children; Grivetti & Ogle 2000; Fentahun & Hager 2009). Wild plants among other non-timber forest products (NTFP) can serve as a "safety net", an emergency help in times of hardship, to avoid becoming poorer or slipping into poverty. In some cases, they can help in poverty mitigation, if they are intensively managed, helping to secure a long-lasting improvement in people's socioeconomic situation (Sunderlin & Huynh 2005).
- They play an important role in times of famine and scarcity, as they are available as an alternative to crops during times of drought, food shortages between crop harvests or conflict-driven famine and periods of unrest (Gordon & Enfors 2008; Muller & Almedom 2008; Aryal et al. 2018). As a result, this food group has sometimes an added stigma of the past, of harsh times and of poverty (Ogle et al. 2001b).
- They have the potential for domestication and are valuable sources of useful traits and genetic characteristics for the breeding of new crops (Hajjar & Hodgkin 2007; Ford-Lloyd et al. 2011).
- They can fulfil variety of functions. Utilization as medicine or feed for livestock is common (Ogle et al. 2003; Ashagre et al. 2016; Berihun & Molla 2017; Chauhan et al. 2018).

2.2. Importance of Wild Edible Plants in Vietnam

Vietnam possesses a rich diversity of both cultivated crops and wild-harvested species, used for their dietary or medicinal values. Fresh ingredients and an array of herbs and vegetables are typical for Vietnamese cuisine. As much as 600 species have been previously described in the literature to be utilized as vegetables (Ogle et al. 2001b and references therein). Wide variety of plant parts is consumed, from roots to flowers that are prepared in soups, pickles, stir-fries, rolls or consumed fresh. Many are wild harvested, especially in rural areas, and can constitute a significant component of the diet (Trinh et al. 2003).

The hill tribes and other minority groups in Vietnam have been closely associated with forests for centuries and ethnicities like Dao, H'mong and others, still tend to live closer to the forest and upland regions. They also tend to have lower income households and wild plants are especially important for these communities in Vietnam as food, medicine or source of income. Although, wild edible plants, "Rau Dai" are part of everyday life across the whole Vietnam. A recent survey from Southern Vietnam by Sang et al. (2012) confirmed that all surveyed households and respondents gathered and collected wild edible forest species, primarily for daily food.

Typically, they played an important role in times of hardship. In Mekong Delta during a period of lower availability of vegetables due to flooding, wild species contributed 81% of daily vegetable intake (Ogle et al. 2001a).

Interestingly, during the Vietnam war, soldiers learnt to use wild plants as a source of food to enrich their diets. They avoided bright coloured or extravagant shaped plants or plants producing latex with exception of *Ficus* spp. to eliminate the risk of poisonous plants (Tanaka & Nguyen 2007). Much later, in 1994, the Army of the Socialist Republic of Vietnam publishes a rather unconventional book for military publishing house: Wild Edible Vegetables of Vietnam (Một Số Rau Dai Ăn Được Ở Việt Nam). It was written based on manuals that were published since 1954 to help dispersed Vietnamese forces to survive and fight with the help of available sources in the wild. 128 of plant species and their uses were described in detail. They were clearly considered medicine as well

as food, as information included also treatments of various medical problems. This unique publication clearly shows the importance of wild species to the Vietnamese military (Thompson 2003).

Wild species are frequently used in multiple ways. Edible species are commonly used also for their medicinal properties and several studies linked WEPs to the local medicinal knowledge and practices (Etkin & Ross 1982; Ogle et al. 2003; Abbasi et al. 2013). Moreover, wild plants are often used also as feed or medicine for livestock, for spiritual or magical practices, as ornamentals or fuelwood (Ju et al. 2013). According to research from the Mekong Delta and Central Highlands in Vietnam by Ogle et al. (2003), apart from the dietary role, around one-third of species had also therapeutic function and 40% of plants were used as feed for livestock.

The multipurpose use of edible species is not unusual also for other parts of the world and has been documented in various ethnobotanical studies (Wujisguleng & Khasbagen 2010; Jain et al. 2011; Ju et al. 2013; Sujarwo et al. 2015).

The “medicinal” function of these plants may be the contribution of important micro and macronutrients to their diet (Ogle et al. 2003). Nevertheless, some common wild Vietnamese food species as *Centella asiatica* (Apiaceae), *Piper* spp. (Piperaceae), *Crassocephalum crepidioides* (Asteraceae) or *Diplazium esculentum* (Athyriaceae) contain therapeutic compounds and have proved medicinal properties (Gohil et al. 2010; Amoroso et al. 2014; Adedayo et al. 2015; da Silva et al. 2017). Mai et al. (2007) in a survey of Vietnamese wild food plants identified four species (*Syzygium zeylanicum* (Myricaceae), *Cleistocalyx operculatus* (Myrtaceae), *Horsfieldia amygdalina* (Myristicaceae), *Careya arborea* (Lecythidaceae)) that demonstrated strong α-glucosidase inhibitory and antioxidant activity as well as significantly high polyphenol contents.

Wild plants hold also important economic potential and are often commercialized. Income from medicinal plants gathered from the wild help the local communities to sustain their families. The district and city of Sapa, situated in the northernmost region of Vietnam, is one of the poorest in Vietnam, however nowadays also a popular tourist destination for Vietnamese or foreign visitors. The existing market in Sapa attracts

mostly sellers form ethnic minorities, as Hmong and Dao people, from villages scattered throughout the surrounding mountains. The weekly markets are important for the economic and social lives of local people and may be the main source of income for many households. These local plants are also sold to markets in Hanoi or China (Delang 2005). According to a survey by Hoang et al. (2008a), some of the useful plants collected in Bến En National Park in Central Vietnam were also commercialized and contributed 12% of the average income of individual households. The most important for income generation were bamboo shoots of *Schizostachyum funghomii* (Poaceae). Other species collected from the forest and sold were e.g. *Schefflera* spp. (Araliaceae), *Dioscorea* spp. (Dioscoreaceae), *Garcinia* spp. (Clusiaceae), *Meliantha suavis* (Opiliaceae) or *Erythropalum scansens* (Olacaceae).

2.3. Nutrition, malnutrition and WEPs in Vietnam

During past decades, Vietnam has achieved significant results in food production, when from a net importer of staple food during the 1980s went to the top rice exporters in the world. Malnutrition rate has gone from 22% down to 10% in 2017 (FAO 2018) and the nutrient intakes increased significantly (Hoang 2009). Howbeit, as a result of the rapid development, the developed-world health issues as obesity have quickly emerged. Albeit, there are important differences in food patterns between regions. In the urban areas of big cities, obesity is growing rapidly. The prevalence of childhood obesity or overweight in Hai Phong City is more than 20% (Hoang et al. 2018). While in the Northern Midlands and Mountainous and the Central Highlands, regions dominated by ethnic minority groups, hunger and malnutrition have not been completely eradicated (NIN 2010; Huong & Nga 2013). According to the survey from 2013, almost half of the children under five years in northeastern Lạng Sơn province were malnourished (19.7% underweight, 27.6% stunted; NIN 2013). Even on the national level, underweight malnutrition is considerably higher among ethnic minority children compared to Kinh majority (30% versus 18%; UNICEF 2010).

The insufficient diets are the main cause of micronutrient deficiency, a form of malnutrition often referred to as “hidden hunger”. Micronutrient deficiencies are a significant public health problem particularly in Southeast Asia and are critical maternal and child health concerns in Vietnam (Seshadri 2001; Huy et al. 2009; Bhutta et al. 2004). The micronutrients that are mostly lacked in Vietnam are Zinc, Iodine, Vitamin A and Iron (Hoang 2009; Laillou et al. 2012). Three main strategies to address micronutrient malnutrition include supplementation, food fortification and diet diversification (Kennedy et al. 2003). While taking supplements quickly deals with micronutrient deficiency, diet diversification is a long-term and sustainable solution (Pritwani & Mathur 2015).

Wild edible plants can significantly contribute to diet diversification and nutrition. Nevertheless, their nutritional role can be neglected, as official nutritional studies often used to omit wild plants, also termed as “hidden harvest” (Scoones et al. 1992), and studies focused on their real contributions to people’ diet are scarce (Boedecker et al. 2014).

In Vietnam, a great range of vegetables have been an essential part of diets, but Ogle at al. (2001a) documented how wild plants can contribute to micronutrient intake. In a study from the Mekong Delta, WEPs were described to make important contributions to nutrients intake of β-carotene, Vitamin C, calcium and iron for local communities (Ogle et al. 2001a). In other studies, wild vegetables contributed significantly to the overall micronutrient intake of mostly carotene, vitamin C and Calcium, but also Iron, Thiamine, Riboflavin and Niacin (Ogle et al. 2001b), and to 21% and 14% of the folate intake of women in the Mekong Delta and the Central Highlands, respectively (Ogle et al. 2001c). An analysis from 2004 found high polyphenol content in herb species and wild vegetables commonly consumed in North Vietnam (Thu et al. 2004). Wild vegetables are also an important source of folate, based on the study by Ogle et al. (2001c). Local vegetables contributed approximately one-third of the daily folate intake, of which significant part were wild species (42% – 72%).

Wild edible plants are not only rich in nutrients but anti-nutritional substances present in many wild species should be appropriately acknowledged as well. Many

domestication efforts are focused on the reduction of these undesired compounds. High levels of antinutritional substances in wild plants relate to their function in plant protection against bacterial or insect attacks as well as against herbivores (Ogle et al. 2001d). They are secondary plant products as saponins, flavonoids, alkaloids, tannins, oxalates, phytates and many others. Antinutritional factors interfere with metabolic processes and bioavailability of nutrients is negatively influenced. Apart from their antinutritive factor, some of them have found a wide application as pharmacologically active agents (Soetan 2008).

Nonetheless, there is a lack of updated and complex studies analyzing the actual importance of WEPs for communities in Vietnam and their contribution to local diets.

2.4. Ethnobotany and Vietnam

Societies have been exploring the relationship between humans and plants and animals for hundreds of years (Ford 2011), however, the year 1874 can be considered the beginning of academic ethnobotany, back then so-called “Aboriginal botany” (Powers 1874). As at first the new discipline was distinctly American, focused on North American Indians, and mainly utilitarian, it took almost a century for the first Southeast Asia study (Bisset 1972; Hidayati et al. 2015). Typically, like many other first ethnobotanical studies, they were focused on medicinal plants, while the systematic study of wild edible plants is more recent.

Today, the central problems of ethnobotany research are the relationships between plant diversity and cultural diversity. The ethnobotanical surveys contribute to the knowledge of current uses and perception of plant species, its sustainability, contribution to livelihood and plant conservation status, and are also valuable in the long-term management of plant resources and conservation strategies (de Albuquerque & Hanazaki 2009; Pieroni and Giusti 2009).

Being a complex field, ethnobotany has been using various methods and theories mainly from botany and anthropology, but from ecology, genetics, evolution, and

economy as well. It can be classified into ethnobiology, which encompasses a wide range of other sub-disciplines such as ethnozoology, ethnoecology, ethnopharmacology, ethnomedicine, ethnomycology, and ethnoveterinary, with often amorphous boundaries (Conklin 1954).

In the past, there were several concerns with the methodologies frequently used and with a perceived lack of methodological advances in contemporary ethnobiology (Stepp 2005). Researchers used to rely on listing and descriptive studies, while inconsistent project designs, diverse field and laboratory methods used in the past made study comparisons challenging.

Since the 1980s, tools of quantitative ethnobotany are commonly used to analyze the data. Quantitative ethnobotany helps in this quantification of otherwise qualitative data using cultural importance indices (Hoffman & Gallaher 2007). The main goal is to measure the plant taxon's relative importance for a specific group of people. A wide variety of them have been developed (Hoffman & Gallaher 2007 and references therein; Tardío & Pardo-de-Santayana 2008) since the emergence of first "use values" index by Prance et al. (1987), later modified by Phillips and Gentry (1993a, 1993b). The appropriate use of these indices allows hypothesis-testing, statistical and comparative analysis.

Considering rich biodiversity of Vietnam, the number of published ethnobotany studies and books on WEPs remains still limited (Gyai et al. 1994; Ogle et al. 2003; Tanaka & Nguyen 2007; Hoang et al. 2008a; Sang et al. 2012; Whitney et al. 2016; Vu & Nguyen 2017). According to a survey from 2015 by Hidayati et al., Vietnam ranked 5th when numbers of scientific papers on ethnobiology in Southeast Asia were compared. Showing countries of the similar area as e.g. Malaysia or the Philippines had been studied more, hence the potential of Vietnam has not been fully explored and ethnobiology has not reflected the existing biocultural diversity adequately.

The most recent study (Vu & Nguyen 2017) specifically focused on mountainous areas of Northern Vietnam, the diversity of neglected wild vegetables and medicinal plants and their nutritional values. The team documented seventy-seven plant species,

including 50 leafy vegetables, 9 root and tuber crops, 11 edible wild fruits, 3 legumes and 4 other types.

Several more ethnobotanical studies were completed with a focus on plant species with medicinal properties (Sowerwine, J. 1999; Tran & Ziegler 2001; Van On et al. 2001; Ogle et al. 2003; Thu et al. 2004; Hoang et al. 2008b; Hoang 2012; Kurian 2012; SPERI 2013). Wild plants often resulted having multiple functions (Ogle et al. 2003). Within the limestone areas of Lạng Sơn province alone, it has been estimated that approximately 150 plant species possess valuable medicinal properties (Nguyen & Vu 1999).

Studies focused on nutritional value of wild plants (Grivetti & Ogle 2000; Ogle et al. 2001a; Ogle et al. 2001b; Ogle et al. 2001c) or agrobiodiversity (Trinh et al. 2003; Canh et al. 2005; Tran-Hong 2007; Vlkova et al. 2011) in Vietnam were conducted in the past as well.

Until now, there was no comprehensive ethnobotanical study made in HLNR or Lạng Sơn province. The only limited ethnobotany information from HLNR is from basic vegetation survey by Frontier Vietnam (Furey et al. 2002). The authors noted use categories (medicine, food, timber, essential oils, fatty oils, ornamental, sap, dye, paper meal, building materials) of some plant species identified in forest plots. There is also a lack of studies on the impact of their harvest from the wild and their commercialization.

2.5. Statement of the problem

Local people in Vietnam have highly relied on edible forest plant resources for generations and have accumulated traditional knowledge about plants and environment they live in. However, the biodiversity is seriously threatened, mostly due to the rapid development, population growth and loss of habitat.

The entire country of Vietnam was once covered in tropical forest, but they have been reduced significantly in the 20th century. Only around 1% could be described as pristine in whole Vietnam. The northern mountains experienced the greatest decline, with forest cover dropping from 95% to 17% between 1942 and 1991 (WWF 1998). Although forest cover has since increased in Vietnam, deforestation and forest degradation continues (JICA, 2012). Furthermore, the population of the highlands has been increasing through natural growth and immigration. During the period of 1980s, over 500,000 migrated into the highlands and this rapid population growth has resulted in clearance of forest land for agriculture and increased exploitation of forest products.

Considering the significant changes and development Vietnam has been going through in past decades, the traditional knowledge about plants and their uses is threatened. It is fast disappearing and at risk of being lost. Moreover, there is very limited number of complex ethnobotanical studies from Vietnam up to date focused in detail on food plants and their importance for local communities and their diets. Wild plants are part of the genetic and cultural heritage that needs to be conserved. Additionally, wild edible plants as attractive sources of micronutrients and bioactive compounds need recognition as important contributors to human nutrition.

Therefore, this study aims to documents edible wild plants diversity and characterizes their use in Huu Lien Nature Reserve. Documentation of these useful species may provide basic information for conservation, possibly further sustainable exploitation, and will preserve local traditional knowledge. Moreover, it is important to identify people who harvest wild plants, their preferences and determine how dependent they are on collecting for their livelihoods, in order to help design appropriate forest management strategies.

3. Aims of the Thesis

In general, the objective of this thesis was to describe the diversity edible plants and related ethnobotanical knowledge of the local people in Huu Lien Nature Reserve, Vietnam. Additionally, a description of the study area and summary of previous ethnobotanical studies was provided.

To preserve and asses the importance of local knowledge the specific aims of this study were to:

- Identify and document the diversity of local wild edible plants
- record the local ethnobotanical knowledge of wild edible plants
- identify the plant species locally used and determine culturally most important species
- review the nutrient composition of the most significant species.

4. Methods

4.1. Demography of informants

In total, 49 respondents (24 females and 25 males) were interviewed, whose age ranged from 14 to 70 (mean age 43 years). 34 informants were from the Huu Lien Nature Reserve, while 15 were from the nearby Yên Thịnh village. The majority of local inhabitants and informants belongs to Kinh ethnicity (68%), the other present ethnic groups were represented significantly less: Dao (20%), Nung (6%) and Tay (6%). A local school provides an only primary and secondary level of education and agriculture forms the predominant source of income generation within Huu Lien Nature Reserve. Although as it was mentioned before, the precise information about education level achieved, and occupation was not obtained. Few informants mentioned running a small-scale local business.

4.2. Data collection

Research was conducted mainly in communes within the Huu Lien Nature Reserve, but Yen Thinh commune was also included to smaller extent. Yen Thinh is the closest settlement from HLNR, only approximately 5 km from its southern border. Previously described as part of HLNR or buffer zone.

The Nature Reserve headquarters and basic facilities for local rangers could be found at the southern border of the Reserve, available also for visiting researchers. Therefore, all research time could be spent in the reserve and within local communities.

The ethnobotanical survey was done during summer months of June and July of 2017. Households were randomly chosen from both localities. Interviews were conducted by visiting informants at their homes while only one member per household was interviewed. All ethnicities, genders and age categories were included.

Firstly, the local authorities were notified, and all necessary permissions were obtained beforehand. All informants were interviewed and talked to in Vietnamese by a native speaker. Following the international codes of ethics, the purpose and details of the study were explained, and prior informed consent was obtained before the interviews took part (Rosenthal 2006). For convenience reasons and to avoid pressuring too much the informants, only oral consents were received. All interviews were accompanied by an officer from local Commune People's Committee, with special attention devoted to interviews with minorities. However, he did not join or influence the interviews.

In the first place, basic personal information was noted (age, sex, ethnicity). The occupation and level of education were not asked as the informants did not feel comfortable sharing this information, mostly due to only basic elementary education achieved and being farm workers.

Later, free listing of ethnospecies and semi-structured interviews were done with the participants. Free listing consisted of asking participants to spontaneously list the name of all the non-domesticated edible plants they knew and their knowledge of each plant (Martin 2004, Reyes-García et al. 2006). The collected ethnobotanical information consisted of local plant name, plant part used, way of consumption or preparation, collecting season, habitat and cultivation status. More in depth, unstructured interviews were held if the informant had broader knowledge, mostly about additional uses or present and past abundance. Additionally, all interviews were accompanied with direct observation of participants (Martin 2004). The local market was visited twice for inspection of species sold locally.

The informants were asked to collect species mentioned in the interviews in order to make voucher specimen. This was not possible with every informant as many species are found in rough mountainous terrain and therefore not easily accessible or were not available due to seasonality. It also took extra time and effort which not everybody was willing to provide. Found species were photographed in their natural habitat, tagged, pressed and dried or preserved in ethanol. Specimens were later identified with help from the Vietnam Academy of Agricultural Sciences in Hanoi, Institute of Ecology and

Biological Resources in Vietnam, where the voucher specimens have been deposited. All species names were verified on the Plant List website (www.theplantlist.org) and classified into botanical families according to APGIV system.

4.3. Data processing

The interviews and the collected data were processed into use-reports (UR) using Microsoft Excel. One use-report corresponds to a respondent mentioning a distinct individual use of a plant part fitting a specific use category. All categories chosen for analysis (plant parts, way of use and preparation) were adapted from the Economic Botany Data Collection Standard (Cook 1995), based on the information provided from participants.

By conversion of data into use-reports, following indices commonly used in quantitative ethnobotany were calculated to analyse the cultural importance of recorded species: 1) *Relative frequency of Citations*; 2*) Smith's Salience*; 3) *Cultural Value*. Microsoft Excel was used to calculate indices and basic statistical information. The salience values were calculated using AnthroTools package (Purzycki & Jamieson-Lane 2016) for free, open-source statistical programming language R (R Core Team 2012). The used software programs were R 3.4.2 and RStudio Desktop 1.0.153. The detailed ethnobotanical information about ethnospecies that had been recorded were summarized into the Table 2 with all data available. The values of all indices calculated on every species are listed in Appendix I.

Furthermore, the maps of the study area and Huu Lien Nature Reserve were prepared using ArcMap 10.5.1 (Figures 1, 2).

4.4. Quantitative data analysis

1) Relative Frequency of Citations (RFC)

The *local importance* of each recorded plant species can be evaluated by the Relative Frequency of Citations, an index commonly used in ethnobotanical studies. The most popularly used plant species will get the highest number for the citation frequency among the community members. It was calculated using following formula (Tardío & Pardo-de-Santayana 2008; Bano et al. 2014):

$$\mathrm{RFC}_s = \frac{\mathrm{FC_s}}{\mathrm{N}} = \sum_{i=i_1}^{i_N} \frac{\mathrm{UR}_i}{\mathrm{N}}$$

$$0 < \mathrm{RFC_s} < 1$$

where FC_s (Frequency of Citations) is the number of informants who mentioned the use of the plant species *s*, and *N* is the total number of informants *(N = 49).* The calculated value varies from 0, nobody refers to the plant as useful, to 1, all the informants mentioning it as a useful species. RFC index does not take in consideration use categories *(u)* and number of Use Reports.

2) Smith's Salience (SS)

Salience value is calculated from data gathered during free-listing. People asked to recall information, tend to recall the most significant ones first (Martin 2004). This assumes that the plants mentioned first and more frequently by informants tend to be the more salient in their cultural domain. The Smiths salience index (Smith's S), developed by Smith (1993), takes into account the frequency of citation of an item and the average rank of the item across all free lists collected, where each list is weighted by the number of items in the list. Resulting scores reveal the greatest cognitive and cultural significance.

The salience scores were calculated as described by Purzycki and Jamieson-Lane (2016) using R and AnthroTools package. The collected data were transformed into table with three columns according to arguments required:

I. Subject - contains code for each informant. Each subject (informant) has a unique identifier in this column.
II. CODE – name of listed species
III. Order - contains the "Order" information of every mentioned species. For each subject responses should be ordered uniquely from 1 to N, where N is the number of responses.

Item order indicates the salience of a specific item (species) for individuals. If first mentioned item has a salience score of 1, the individual silence is the inverse order of items listed divided by the total number of items listed. The following formula was used to calculate the Item salience value:

$$\text{Item salience}_s = \frac{(\mathrm{n}_i + 1 - \mathrm{k}_{si})}{\mathrm{n}_i}$$

where *k* is the order of species listed and *n* is the total number of species listed by an informant *i*.

Three types of Salience value are calculated using the Anthropack package: the Mean Salience, Summary Salience and Smith's Salience. For analysis in this work, the latter was used. The results were rescaled such that the sum of Item saliencies of every informant is 1, to prevent respondents with unusually long answer lists from dominating the analysis.

3) Cultural Value (CV)

The *relative importance* of locally used species can be assessed by the Cultural Value Index. Unlike the previous indices, the Cultural Value index considers different use categories *(u)* as well. This index was first introduced by Reyes-García et al. (2006) while the following formula was used for the calculation in this work (Tardío & Pardo-de-Santayana 2008):

$$\mathrm{CV}_s = \frac{\mathrm{NU_s}}{\mathrm{NC}} \times \frac{\mathrm{FC_s}}{\mathrm{N}} \times \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} \frac{\mathrm{UR}_{ui}}{\mathrm{N}}$$

$$0 < \mathrm{CV_s} < \mathrm{NC}$$

It consists of three factors: (1) the relationship between the number of different uses *(NU)* of a cited species and the total number of use categories *(NC)* identified in the study, (2) the Relative Frequency of Citation as previously defined and (3) the sum of all use reports for all use categories *u* per the total number of participants *(N = 49).*
The range of possible values is from 0 to the number of use categories *(NC).*

5. Results

5.1. Comparison of Huu Lien Nature Reserve and Yen Thinh village

Interestingly, there seem to be great difference in the collecting pattern between the two visited communities, as can be seen on Figure 4. The great majority of informants in Huu Lien Nature Reserve are still active in WEPs collecting, while almost two thirds of informants from Yen Thinh already stopped.

However, respondents from Huu Lien mentioned 3 species more on average compared to respondents from Yên Thịnh (8 and 5 respectively). The diversity of cited species was also very much lower for Yên Thịnh commune, only 18 species in contrast to 57 different ethnospecies mentioned by informants from Huu Lien Nature Reserve (17 species were shared). However, it must be taken in consideration that higher number of participants were from Huu Lien commune which could introduce some bias.

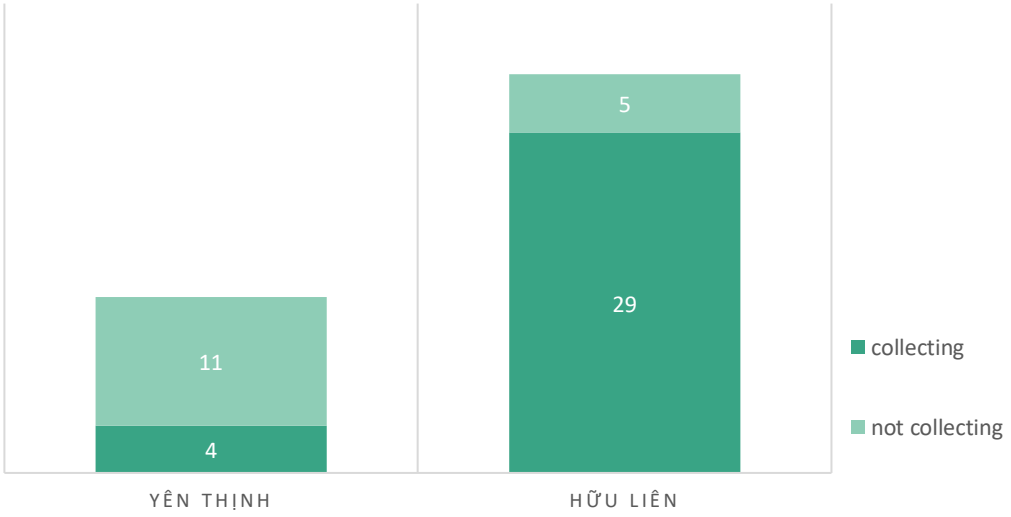

Figure 4. Number of participants actively collecting WEPs, comparison of Huu Lien and Yen Thin communities

5.2. Diversity of Wild Edible Plants

In this study, informants mentioned more than 90 vernacular names describing the use of 58 local wild food species. These ethnospecies were identified to 46 botanical taxa, but 12 of them were identified only down to genus. Also, twelve other ethnospecies were not identified or a specimen could not be collected.

The documented species are distributed in 35 families and 42 genera. The families with most species recorded (3 species) are *Anacardiaceae, Moraceae*, and *Rutaceae.* The absolute majority (74%) of recorded families are represented only by one species. On the other hand, the most cited families were *Sapindaceae*, *Theaceae* and *Opiliaceae*. Botanical families with the number of species and use reports are listed in Table 1.

Table 1. Botanical families recorded

BOTANICAL FAMILY	SPECIES	*% UR*	UR	BOTANICAL FAMILY	SPECIES	*% UR*	UR
Sapindaceae	2	*13.6*	51	Oxalidaceae	1	*1.1*	4
Theaceae	1	*12.6*	47	Saururaceae	1	*1.1*	4
Opiliaceae	1	*11.8*	44	Actinidiaceae	1	*0.8*	3
Rutaceae	3	*11.2*	42	Brassicaceae	1	*0.8*	3
Anacardiaceae	3	*6.4*	24	Myrtaceae	2	*0.8*	3
Erythropalaceae	1	*5.9*	22	Pandanaceae	1	*0.8*	3
Vitaceae	1	*5.6*	21	Rosaceae	1	*0.8*	3
Moraceae	3	*5.3*	20	Apocynaceae	1	*0.5*	2
Sterculiaceae	1	*3.7*	14	Dioscoreaceae	1	*0.5*	2
Athyriaceae	1	*2.4*	9	Lamiaceae	1	*0.5*	2
Apiaceae	2	*2.1*	8	Arecaceae	1	*0.3*	1
Burseraceae	1	*2.1*	8	Bignoniaceae	1	*0.3*	1
Clusiaceae	2	*1.3*	5	Dilleniaceae	1	*0.3*	1
Gnetaceae	1	*1.3*	5	Flacourtiaceae	1	*0.3*	1
Musaceae	2	*1.3*	5	Melastomataceae	1	*0.3*	1
Piperaceae	1	*1.3*	5	Simaroubaceae	1	*0.3*	1
Asteraceae	1	*1.1*	4	Zingiberaceae	1	*0.3*	1
Euphorbiaceae	2	*1.1*	4				

The dominant life forms were trees (45 %), followed by herbaceous plants (23%), climbers (17%) and shrubs (15%). The proportion of different plant life forms is shown in the Figure 5. The most abundant life forms were woody plants, representing together 60% of recorded species.

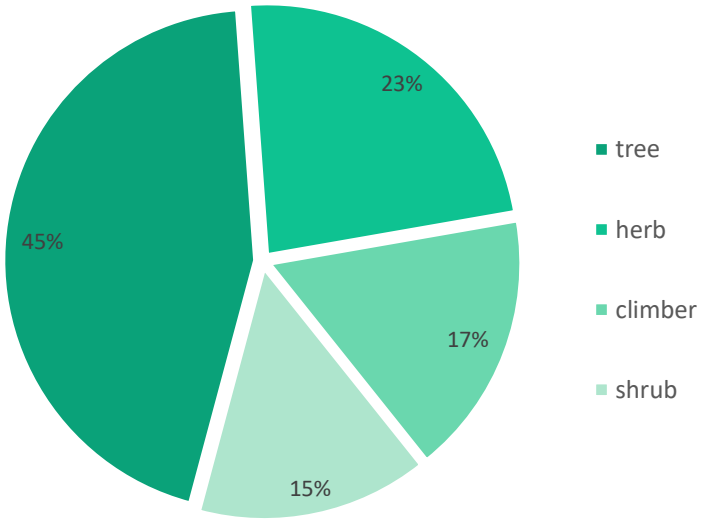

Figure 5. Share of plant life forms of recorded species

5.3. Edible parts, Use Categories and Ways of Preparation

Various plant organs were used with food purposes, but the fruits were by far the most consumed parts. A fruit was stated to be used in 72% cases (310 UR), followed by leaves (14%; 61 UR) and shoots (7%; 32 UR). Other plant parts as seeds (13 UR), fronds (9 UR), flowers (2 UR), tubers (2 UR), sap (1 UR) and fruit skin (1 UR) were used rarely (3 - 0.2%; 1-9 UR). Figure 6 shows the share of different parts used as food.

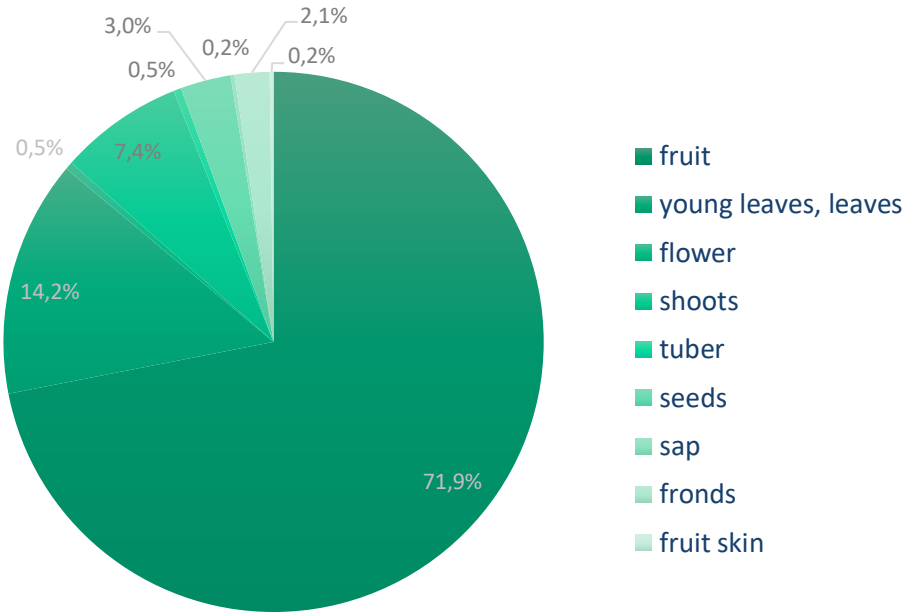

Figure 6. Edible parts (share of use reports)

The main use categories of identified wild food species were snack, vegetable, beverage, flavouring and preserve.

Majority of species were used as snacks (278 UR). Snacks are consumed as a refreshment usually when found in forest or also brought to the village. These were mostly fruits that are collected when in season while other activities are being done in the forest and to supplement the diet.

Seven species were used for various beverages (19 UR), alcoholic or non-alcoholic, including *Gnetum* sp. that offers a drinkable sap. In 23% of cases (101 UR) the plants were consumed as vegetables. Two distinct types of flavourings were found to be used in HLNR. Six species of sour fruits or leaves are utilized as souring agents (15 UR). They are added typically to a fish soup, at the end of cooking. Four species (11 UR) are used as seasoning for their aromatic leaves. In twelve reports the species were cited to be used as preserves. These include

The species and use reports share are illustrated on Figure 7.

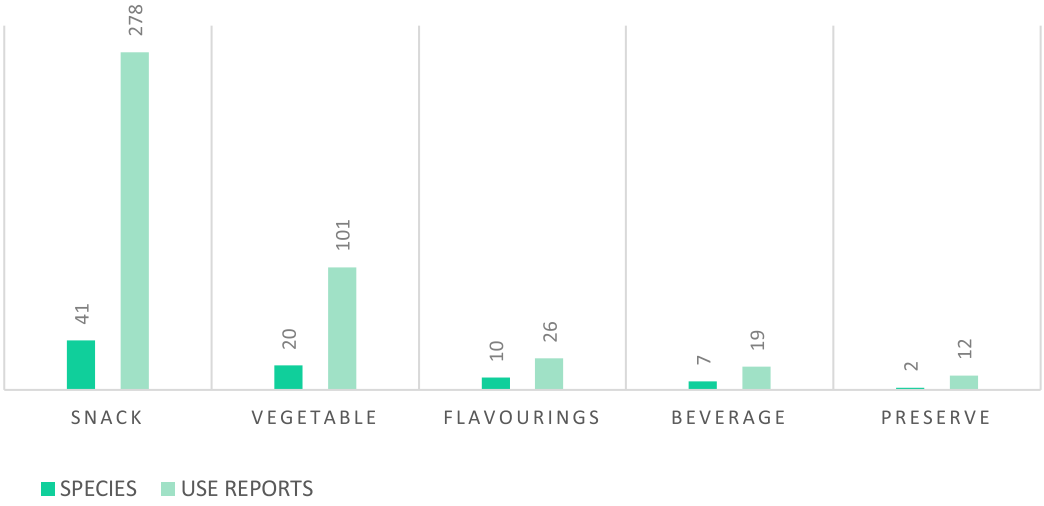

Figure 7. Main use categories of WEPs reported

Even though it was not the focus of the survey, informants mentioned also additional uses of cited edible species. Almost half, 42% of ethnospecies, were reported to be used for other than food, medicinal use being the most common. They were utilized as construction wood, firewood, fodder for animals or for packaging.

The collected edible plants and their parts were consumed in various ways, some species required just cleansing of the eaten part, other needed elaborate preparations prior consumption. The most popular was the direct consumption of raw unprocessed plant parts (62% of Use Reports), which was most commonly edible fruit. Some species were used fresh but processed in more complicated meals (5%). Fresh leaves were used raw mixed in salads, as seasoning or in drinks. The leaves of *Ficus racemosa* were used not only in salads but also as spring rolls. However, more often the edible leaves, shoots and other organs were boiled (13%), fried or stir-fried (5%) with other ingredients. Young fronds of *Diplazium esculentum* were stir-fried with garlic, eggs, meat or other vegetables. *Sterculia henryi* or *Gnetum* sp. seeds were fried in oil before consumption. In 10% of cases fruits or other plant parts were cooked in soups (e.g. *Erythropalum scandens, Meliantha suavis*). In total 5% of use reports cited plants being soaked. Fruits of *Clausena indica* were used for Măng ớt, a typical condiment used for breakfast. They

are preserved with other ingredients in salty brine (1%). Other mature fruits were served soaked in water with sugar as a refreshing drink (1%) or soaked in strong alcohol (3%) and drank as local “wine” (Figure III of Appendix 2). Only one species (*Garcinia* sp.) was cited to get dried before being used as an ingredient in soup.

The following Figure 8 shows the proportion of species and use reports for various preparation modes of cited species.

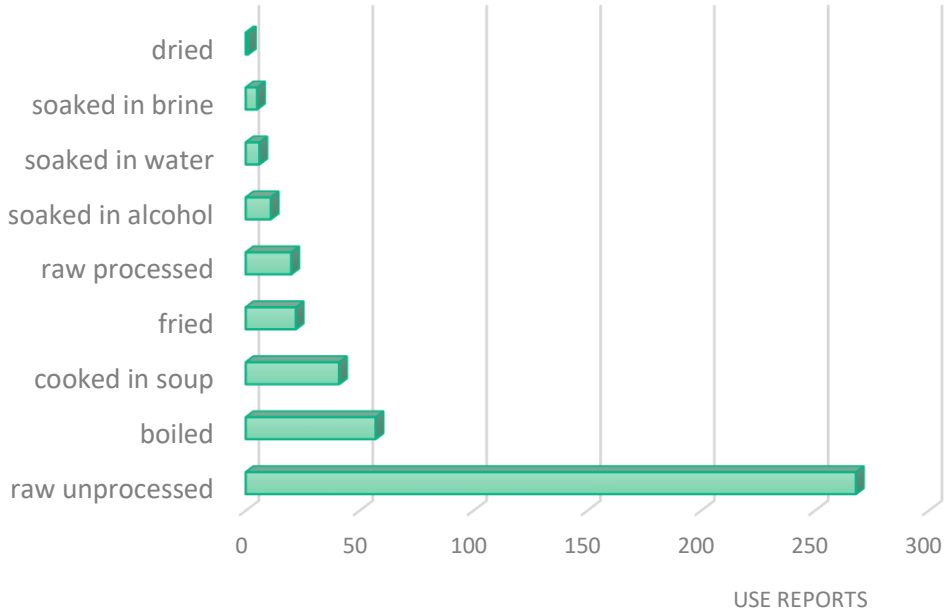

Figure 8. Preparation modes of wild species

5.4. Seasonality and Management

In terms of the degree of management and cultivation status, thirty-seven ethnospecies (65%) were exclusively gathered from wild, while twenty ethnospecies (35%) were mostly collected from wild but were reported by informants to be grown also in home gardens. Several plants were brought from the forest to home gardens but could not be cultivated as they required the specific conditions of limestone karst.

Almost 38% of informants reported selling a wild species at one point in their life. Among the species mentioned were: *Spondias lakonensis, Canarium album, Camellia* sp.*, Clausena* spp.*, Diplazium esculentum, Dracontomelon duperreanum, Erythropalum scandens, Meliantha suavis, Vitis* sp. and *Xerospermum noronhianum.*

Most of the species had their edible parts available only during certain time of the year. Great majority of species were reported to be available during summer season (May - August). Nine species were available during whole year and there is no data in seasonality for five species. The seasonal availability expressed in months is illustrated on Figure 9.

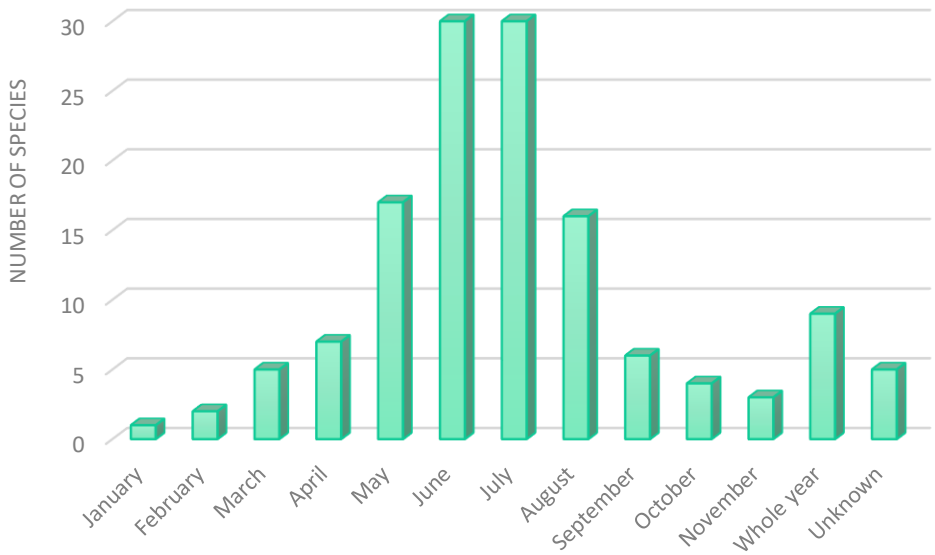

Figure 9. Seasonal availability of collected wild plants

The summary of all ethnobotanical data collected is in Table 2.

Table 2. Summary of ethnobotanical information about wild edible plants in Huu Lien Nature Reserve, Vietnam

BOTANICAL FAMILY SPECIES	VERNACULAR NAME	LIFE FORM	EDIBLE PART	USE CATEGORY	MODE OF PREPARATION	CULT. STATUS*	SEASON	ADDITIONAL USE
ACTINIDIACEAE								
Saurauia tristyla Candolle	Nhàu	shrub	fruit	snack	raw	W	June - July	Medicine - leaves
ANACARDIACEAE								
Spondias lakonensis Stapf.	Da, Dâu doa	tree	fruit	snack beverage souring agent	raw soaked in water cooked in fish soup	W, HG	July - August	-
Dracontomelon duperreanum Pierre	Sấu (rừng)	tree	fruit	snack beverage souring agent	Raw soaked In water with sugar cooked in fish soup, added after the vegetables were taken out			-
Mangifera sp.	Queó, Xoài rừng, Xoài núi	tree	fruit	snack souring agent	raw cooked in soup	W	June - November	-
APIACEAE								
Centella asiatica (L.) Urb.	Rau má	herb	shoots	vegetable beverage	boiled raw mixed with water	W, HG	April - September	-

BOTANICAL FAMILY SPECIES	VERNACULAR NAME	LIFE FORM	EDIBLE PART	USE CATEGORY	MODE OF PREPARATION	CULT. STATUS*	SEASON	ADDITIONAL USE
Eryngium foetidum L.	(Rau) Mùi tàu	herb	leaves	vegetable	raw mixed in salad, boiled	W, HG	all year	-
				culinary herb	raw			
APOCYNACEAE								
Aganonerion polymorphum Pierre. ex Spire	Cây lá chua, Chua lam	climber	leaves	souring agent	fresh or dried and cooked in fish soup	W	all year	Sour macerate is used to solidify tofu
ARECACEAE								
Calamus sp.	Mây roi, Quả Mây	climber	fruits	snack	raw	W	NA	-
ASTERACEAE								
Crassocephalum crepidioides (Benth.) S. Moore	(Rau) Tàu bay	herb	leaves	vegetable	boiled, cooked in soup	W, HG	April - May	-
ATHYRIACEAE								
Diplazium esculentum (Retz.) Sw.	Rau dớn	herb	Young fronds	vegetable	boiled as vegetable, with garlic; stir-fried with eggs	W	NA	-
BIGNONIACEAE								
Oroxylum indicum (L.) Kurz	Núc nác	tree	flowers	vegetable	fried in oil	W, HG	NA	Medicine – baked fruit for stomach ache
BRASSICACEAE								
Nasturtium sp.	Cái xoong	herb	leaves	vegetable culinary herb	boiled, with garlic raw	W	All year	-

BOTANICAL FAMILY SPECIES	VERNACULAR NAME	LIFE FORM	EDIBLE PART	USE CATEGORY	MODE OF PREPARATION	CULT. STATUS*	SEASON	ADDITIONAL USE
BURSERACEAE								
Canarium album (Lour.) DC.	Trám	tree	fruits	snack	raw without skin, cut in half and eaten with salt	W, HG	June - August	-
				vegetable	Cooked with meat			
CLUSIACEAE								
Garcinia sp.	Quả Bứa, Bứa, Hong	tree	fruits – pulp	snack	raw	W	July - August	Construction wood
			skin	souring agent	dried and used in fish soup			
DIOSCOREACEAE								
Dioscorea sp.	Củ mài	climber	tuber	vegetable	boiled	W, HG	April - May	-
DILLENIACEAE								
Dillenia turbinata Fin. & Gagn.	Nọt	tree	fruits	snack	raw	W	May - June	-
EUPHORBIACEAE								
Flueggea virosa (Roxb. ex Willd.) Royle	Cây nổ, Quả nổ	shrub	fruit	snack	raw	W	June - July	Medicine – leaves for irritated skin
Strophioblachia fimbricalyx Boerb.	Rau Then	shrub	young leaves	vegetable	cooked in soup	W	January - February	Medicine - bark
FLACOURTIACEAE								
Flacourtia indica (Burm.f.) Merr.	Quanh chau	shrub	fruits	snack	raw	W	March	Medicine – roots, leaves

BOTANICAL FAMILY SPECIES	VERNACULAR NAME	LIFE FORM	EDIBLE PART	USE CATEGORY	MODE OF PREPARATION	CULT. STATUS*	SEASON	ADDITIONAL USE
GNETACEAE								
Gnetum sp.	Gấm	climber	seeds Sap	snack beverage	fried, boiled raw	W	July - August	Feed for wild animals
LAMIACEAE								
Clerodendrum sp.	Bọ mẩy	shrub	shoots	vegetable	boiled	W	summer	-
MELASTOMATACEAE								
Melastoma septemnervium (Lour.) Merr.	(Hoa) Mua	shrub	fruits	snack	raw	W	June - July	-
MORACEAE								
Ficus hirta Vahl	Ngái	Tree	fruits	snack	raw	W, HG	all year	-
Ficus racemosa L.	Sung	Tree	fruits leaves	snack preserve vegetable	raw cut in half in salt solution, with lemon grass, eaten with vegetable or crab soup raw in salad; Spring rolls - rice powder with skin pork is left to ferment for 5h, then rolled in the leaves, eaten with rice wine	W, HG	June - July	Medicine – leaves Fodder - leaves
Ficus auriculata Lour.	(Quả) Vả	Tree	fruits young leaves	snack vegetable	raw raw in salad	W, HG	June - August; whole year	Medicine – root for teeth

BOTANICAL FAMILY SPECIES	VERNACULAR NAME	LIFE FORM	EDIBLE PART	USE CATEGORY	MODE OF PREPARATION	CULT. STATUS*	SEASON	ADDITIONAL USE
MUSACEAE								
Musa balbisiana Colla	Chuối rừng, Chuối hội	herb	flower	vegetable	raw	W	June - July	-
			fruit	beverage	soaked in alcohol			
Musa sp.	Chuối củ	herb	fruit	snack	raw	W	July - August	Fodder – leaves and stem
MYRTACEAE								
Rhodomyrtus tomentosa (Ait.) Hassk.	Sim	shrub	fruit	snack	raw	W, HG	June - July	Medicine - root
Syzygium samarangense (Blume) Merr. & L.M.Perry	(Quả) Roi	tree	fruit	snack	raw	W, HG	July	-
OLACACEAE								
Erythropalum scandens Blume	Bầu bí chai, Bò khai	climber	young leaves, shoots	vegetable	cooked in soup, with meat, stir-fried with eggs	W, HG	except winter	Medicine – mixed with other herbs
OPILIACEAE								
Melientha suavis Pierre	Rau ngót rừng, Rau sắng	tree	young leaves	vegetable	cooked in soup or with meat	W	February - April	-
			fruits	snack	raw		April	
OXALIDACEAE								
Oxalis corniculata L.	Chua me, Chu me, Chua me đất	herb	leaves	vegetable	boiled, raw	W, HG	all year	-
PANDANACEAE								
Pandanus urophyllus Hance	Dứa rừng, Dứa đuôi	tree	fruits	beverage	soaked in alcohol	W	June - July	-

BOTANICAL FAMILY SPECIES	VERNACULAR NAME	LIFE FORM	EDIBLE PART	USE CATEGORY	MODE OF PREPARATION	CULT. STATUS*	SEASON	ADDITIONAL USE
PIPERACEAE								
Piper lolot C. DC.	Lá lốt	herb	leaves	culinary herb vegetable	raw boiled, with meat	W, HG	all year	-
ROSACEAE								
Rubus sp.	Đũm, Dum thuốc	climber	fruits	snack	raw	W	June - July	-
RUTACEAE								
Clausena indica (Dalzell) Oliv.	Mắc mật	tree	fruit leaves	snack preserve culinary herb	raw soaked in brine with chili and bamboo shoots (Măng ớt) Cooked with pork	W, HG	May – July except winter	Construction wood, firewood
Clausena lansium (Lour.) Skeels	Mắc mật rừng	tree	fruits	snack	raw	W, HG	June - July	firewood
Glycosmis parviflora (Sim.) Little	Bí bung	tree	fruits	snack	raw	W	summer	-
SAPINDACEAE								
Dimocarpus longan Lour.	Nhãn rừng	tree	fruits	snack	raw	W	April – July	-
Xerospermum noronhianum Blume	(Quả) Ké, Cây Ké rừng	tree	fruits	snack	raw	W	May - August	Construction, furniture and firewood
SAURURACEAE								
Houttuynia cordata Thunb.	Diếp Cá, Cân dai	herb	shoots	vegetable	raw	W, HG	all year	-
SIMAROUBACEAE								
Brucea javanica (L.) Merr.	Xoan rừng	tree	fruits	snack	raw	W	August	Construction wood

BOTANICAL FAMILY SPECIES	VERNACULAR NAME	LIFE FORM	EDIBLE PART	USE CATEGORY	MODE OF PREPARATION	CULT. STATUS*	SEASON	ADDITIONAL USE
STERCULIACEAE								
Sterculia henryi Hemsl.	Ngoang, Mé Gá	tree	fruits seeds	vegetable snack	boiled raw, fried, boiled	W	June - July	-
THEACEAE								
Camellia sp.	Chà	tree	fruits	snack	raw	W	May - July	Construction wood, firewood
VITACEAE								
Vitis sp.	(Dây) nho rừng, Nho rừng, Nho nho	climber	fruits	beverage snack	mature fruits soaked in alcohol raw	W	April - June	-
ZINGIBERACEAE								
Amomum sp.	Gừng núi	herb	shoots	vegetable	raw	W, HG	NA	medicine
UNIDENTIFIED								
	Cận	tree	fruits	snack	raw	W	Sept - Oct	Construction wood
	Chà lười	climber	fruits	snack	raw	W	May	-
	Dai	climber	fruits	snack	raw	W	Sept - Nov	-
	Dây vú sữa, Vú (sữa) bó, (Dây) vú bó, Quả vú bó	climber	fruits	snack	raw	W	May - September	-
	Đéo, Mai téo	tree	fruits	snack	boiled, fried	W	NA	-
	Hồng tháp	tree	fruits	snack souring agent	raw cooked in soup	W	August	Packaging - leaves

BOTANICAL FAMILY SPECIES	VERNACULAR NAME	LIFE FORM	EDIBLE PART	USE CATEGORY	MODE OF PREPARATION	CULT. STATUS*	SEASON	ADDITIONAL USE
	Lâu	tree	fruits	snack	raw	W	Sept - Nov	Construction wood
	Lồm côm	tree	fruits	snack	raw	W	August	Construction wood
	Lưới chó	climber	fruits	snack	raw	W	May	-
	(Quả) Lọong	tree	fruits	snack	raw	W, HG	June - Aug	firewood
	Tac	Tree	fruits	snack	raw	W	May - June	-
	Vong	tree	Fruits	snack	raw	W	May - July	firewood

*CULTIVATION STATUS: W (collected from wild), HG (grown in home garden)

5.5. Quantitative ethnobotany

Quantitative value indices were calculated in this study to analyze the recorded ethnobotanical information. In total, 431 Use Reports were collected and evaluated with three indices.

The comparison of all calculated indices showed a distinct group of plants with the overall highest scores. The Table 3 shows the ranking of the following twelve species considered to be the most important based on the quantitative measures: Camellia sp. Xerospermum noronhianum, *Melientha suavis, Clausena indica, Clausena lansium, Erythropalum scandens, Vitis* sp.*, Sterculia henryi, Dimocarpus longan, Spondias lakonensis* and also unidentified ethnospecies 'Vong' and 'Vú sữa bó'. The values of all indices calculated are shown in Table 4 of Appendix I.

Table 3. Ranking of plant species with the top ten scores for quantitative indices

	UR[1]	FC[2]	RFC[3]	SS[5]	CV[6]
	Camellia sp.	*Camellia* sp.	*Camellia* sp.	*Camellia* sp.	*M. suavis*
2	*M. suavis*	*X. noronhianum*	*X. noronhianum*	*X. noronhianum*	*Camellia* sp.
3	*X. noronhianum*	'Vong'	'Vong'	'Vong'	*X. noronhianum*
4	'Vong'	*M. suavis*	*M. suavis*	*M. suavis*	*C. indica*
5	*C. indica*	*E. scandens*	*E. scandens*	*E. scandens*	'Vong'
6	*E. scandens*	*C. indica*	*C. indica*	*Vitis* sp.	*Vitis* sp.
7	*Vitis* sp.	*C. lansium*	*C. lansium*	*C. lansium*	*E. scandens*
8	*C. lansium*	*Vitis* sp.	*Vitis* sp.	*C. indica*	*S. henryi*
9	*S. henryi*	*S. henryi*	*S. henryi*	*D. longan*	*C. lansium*
10	*D. longan*	'Vú sữa bó'	*D. longan*	*S. henryi*	*S. lakonensis*
	'Vú sữa bó'	*D. longan*	'Vú sữa bó'	'Vú sữa bó'	

[1] UR (Use Reports); [2] FC (Frequency of Citation); [3] RFC (Relative Frequency of Citation); [4] UV (Use Value Index); [5] SS (Smith's Salience Index), [6] CV (Cultural Value Index); Vong and Vu sữa bó' are unidentified species

6. Discussion

6.1. Importance of wild edible species for local communities

Around two-thirds of the interviewed participants (67%, 33 participants) stated to actively collect wild edible plants until this time. Fifteen informants (30%) do not collect anymore from various reasons (pregnancy, high age) but did in the past and still use them nowadays if possible. Only one participant stated to never collect any wild plants and was not able to recall knowledge about any wild species. Such high participation in wild plants collection in Vietnam was reported also by other authors. Study by Hoang et al. (2008a) revealed that 60% and 40% of men and women respectively collected forest resources, while according to a study by Sang et al. (2012), 100% of households surveyed in Cat Tien Biosphere Reserve harvested some or many plant species.

Vu and Nguyen (2017) noted that in Vietnam women in general seem to possess extensive knowledge on collection and utilization of wild plants. While Hoang et al. (2008b) states same results for collection of medicinal plants. In HLNR, there was small difference in the average numbers of reported species, as on average approximately 8 and 7 species were reported by females and males respectively. However, women possessed the knowledge about less used and rare species, as the most knowledgeable respondents citing ten or more species (maximum 23) were only women.

6.2. Diversity of wild edible species in HLNR

In this study, 58 ethnospecies were described by more than 90 different names and their variations. 46 of them were identified down to species or genus. Vietnamese vernacular botanical nomenclature can be quite complicated. The distinct northern, central, and southern dialects are reflected by numerous examples of multiple

vernacular names for a single subject and pronunciations for a single word. Different vernacular names are also often referencing to the same species when they are corresponding to its use at different developmental stages or to distinguish the part utilized (Nguyen 2006).

In compliance with Nguyen (2006), the vernacular names reported in this study were often contain descriptive words as '*rau'* (leafy vegetable), '*lá'* (leaves), '*quả'* (fruit), '*cây'* (tree), '*củ'* (corms). Additionally, '*rừng*' was sometimes added to the names for species coming from forest or wild in our case. For example, *Xerospermum noronhianum* was referenced as '*Ké', 'Quả Ké*' or '*Cây Ké rừng'*.

The results show that the most represented families were *Moraceae, Anacardiaceae*, and *Rutaceae*. These plant families are species-rich, containing numerous edible species, wild and domesticated as well. According to recent biodiversity survey by Chu and Nguyen (2015), genus *Ficus* is the most species-rich genus in HLNR. In ethnobotanical studies from limestone karst in Philippines (Rosales et al. 2018) or closely located Southern Yunnan in China (Jin et al. 1999), families Moraceae and Anacardiaceae were among the most represented. However, different species-rich families as Fabaceae, Euphorbiaceae or Zingiberaceae often dominate studies in Vietnam (Ogle et al. 2003; Hoang et al. 2008a-*only food species included*; Sang et al. 2012) or other South East Asian countries (Suksri et al. 2005; Sujarwo et al. 2015). Other families contained mostly one species. This very high diversity is typical and was documented in the previous studies. The actual species composition was comparable to results from Ben En National Park, Vietnam (Hoang et al. 2008a).

Majority of edible parts used were fruits and leaves. Very high diversity of edible fruits in HLNR was documented, in comparison with other Vietnamese ethnobotanical studies, where leafy vegetables were more popular (Ogle et al. 2003; Sang et al. 2012.) However, preference for fruits was common in studies from Indonesia (Sujarwo et al. 2015), Philippines (Rosales et al. 2018), Thailand (Suksri et al. 2005) or India (Chandra et al. 2013; Momin et al. 2016). The plants were stated to be sourced mostly in the limestone forest, but some species were found in the vicinity of settlements, along roads and rice fields (*C. asiatica*, *E. foetidum, F. indica*), secondary grasslands (*Rubus* sp.*, M.*

septemnervium, R. tomentosa), close to streams as well (*D. esculentum, Nasturtium* sp.*, F. virosa*).

Woody plants prevail, comprising more than half of the species (60%). The prevalence of trees and shrubs corresponds to previous studies (Sang et al. 2012; Sujarwo 2015).

Regarding the seasonal availability, most species, especially fruit trees, had season in the summer period. This seasonality is due to more subtropical climate in northern Vietnam with colder and dryer winter. Nevertheless, several species used for their edible leaves and shoots (*Houttuynia cordata, Piper lolot, Oxalis corniculata, Aganonerion polymorphum, Nasturtium* sp.*, Eryngium foetidum, Ficus racemosa, Ficus hirta*) were available during the whole year. *Ficus* species were especially appreciated as old, mature trees were reported to regrow shoots any time of year.

6.3. Diversity of uses

Nearly all reported species have been documented as edible in the scientific literature. However, there was very scarce information on several species, probably due their small range limited to Northern Vietnam and Southern China. Some of these lesser known species, as *Camellia* sp., *Xerospermum noronhianum* or *Spondias lakonensis,* belong among to the most cited ones.

Camellia genus (Theaceae) contains up to 300 species, including some notable as *Camellia sinensis*, widely used for tea. Edible oil is being extracted from the seeds from several species *(C. oleifera, C. japonica, C. chekiangoleosa, C. drupifera, C. furfuracea)*. However, there is no information on fruits being edible, except for *C. kissii,* according to Kunkel and Facciola (as cited in Tropical Plants Database 2019).

One of the most interesting documented species is *Xerospermum noronhianum* (Sapindaceae). 82% of informants reported the use of its edible fruit. However, it is rather poorly researched species; no ethnobotanical, nutritional or pharmacological study has been conducted, except only one study documenting the saponin content in the stem (Jean et al. 2009).

It belongs to the Sapindaceae family and it is closest to *Nephelium* genus (Rambutan) due to the presence of a sarcotesta. It is a subcanopy dioecious tree, growing up to 25 m in various types of tropical forest, on plains and on slopes as well, and on variety of soils, including limestone subsoil. Fruits, small warty drupes, mature from green over yellow to red (Leenhouts 1983). Described by PROSEA (Jansen et al. 2016), the thin sarcotesta is yellow to orange of sweet flavour and it can be eaten raw. However, according to the Flora Malesiana (Adema et al. 1994), they are eaten by birds and monkeys. The timber is also utilized. In HLNR, the timber was stated to be used for construction and as firewood. Figure IV (Appendix 2) illustrates a decorative roof construction made by *X. noronhianum*. As one of the most popular, indigenous fruit tree species, the potential of *X. noronhianum* should be further researched.

Genus *Spondias* contains several species with edible fruits as S*. dulcis, S. pinnata* or *S. mombin,* but there is not much information available for *S. lakonensis.* It seems to be associated with limestone and has been recorded to be utilized locally for edible fruits in Northern Vietnam (Shaw & Forman 1967; Hanelt 2001).

On the other hand, 19 species were reported just by one informant. Almost all unidentified ethnospecies belong to these lowest cited plants. Despite the low citations, several species are documented as edible in scientific literature.

Fruits of *Brucea javanica* are consumed as food and medicine in India (Lalfakzuala et al. 2007) and Nepal (Uprety et al. 2012; Sigdel et al. 2013; Mahato 2015). *Glycosmis parviflora* has spread from its original range (NE Vietnam, S China, Myanmar) to Florida, tropical Africa or even Cuba and Jamaica). The small aromatic fruits with a thin, juicy pulp are consumed (Tafokou 2011; Hassler 2019). The species has been studied also for its medicinal properties (Wu et al. 1995; Greger et al. 1996; Ito et al. 2000; Yasir et al. 2019). *Syzygium samarangense,* although almost completely unknown outside South East Asia, is fairly cultivated fruit tree. It is even economically important in Taiwan (Khandaker & Boyce 2016). *Flacourtia indica* is cultivated nearly everywhere in the tropics of the Old World and less often of the New World. The acidic to rather sweet fruits are eaten fresh (if completely ripe) or used for preserves, jams, jellies and pies. It is also an important Ayurvedic drug (Hanelt 2001).

Other species include *Melastoma septemnervium* or *Strophioblachia fimbricalyx* both native to Northern Vietnam and Southern China, are described as edible (Meyer 2001; Pham et al. 2013), however more detailed information is missing.

Species with no documented edible use are: *Sterculia henryi, Dillenia turbinata* and *Pandanus urophyllus.* Eleven ethnospecies identified just to genus could not be reviewed (*Clerodendrum, Calamus, Garcinia, Mangifera, Nasturtium, Amomum, Vitis, Rubus, Musa, Gnetum).* However, all mentioned taxa had other species from their genus commonly used as food and they should be the subject of further in-depth investigations.

6.3.1. Snacks

This is the largest category in this study, including impressive 41 species. As mostly fruits were used, the most common way of consumption was often without any processing and eaten raw. This is, of course, common for fruits around the world. The fruits were stated to be used as snack, eaten as dessert fruits, supplemental food and often brought as a treat from the forest for children. They were commonly described as consumed at place of collection, collected purposely when in season or when in being the forest for other purposes, as firewood collection.

However, some fruits are processed before consumption. The skin from *Canarium album* fruits is removed, then they are cut in half and eaten with salt. The fruits can also be put in cool water and heated for 5 minutes. Afterwards it is easy to peel the skin and possible to eat the fruit, as the skin can be bitter. If the fruit is unripe (green), it is edible with the stone, otherwise must be removed and only the pulp is edible. A similar way of consumption, raw or salted, has been reported from Southern China (Jin et al. 1999).

In Huu Lien Nature Reserve, three species were cited from *Moraceae* genus Ficus: *F. auriculata*, *F. hirta* and *F. racemosa*. “Figs” are mentioned in an overwhelming number of ethnobotanical studies, documenting the use of fruits, bark, leaves, roots or latex used as food, medicine ornamental trees, religious plants, fodder or fuelwood (Lansky & Paavilainen 2011 and references therein; Shi et al. 2014). Some *Ficus* species belong

among the oldest human food sources (Kislev et al. 2006). While still used wild, thousands of cultivars have been developed worldwide.

Gnetum seeds are fried or boiled and consumed as snack as well. Although the species was not identified, the way of consumption corresponds to documented use of lianoid taxa native to Vietnam: *G. montanum, G. formosum or G.parviflorum* (Fu et al 1999). Another species with edible seed used as a snack is *Sterculia henryi.* The seeds are consumed raw, boiled or fried. As it was discussed previously, *S. henryi* has not been documented as edible previously in the literature. Nonetheless, *Sterculia* genus is species-rich and consumption of several species have been documented in tropical Asia, e.g. boiled seeds of *S. brevissima* consumed in Southern China or *S. foetida* (Jin et al. 1999; Tang et al. 2007).

6.3.2. Vegetables

Twenty species were cited to be used as vegetables. Young leaves and shoots (*Ficus racemosa, F. auriculata, Oxalis corniculata, Eryngium foetidum, Houttuynia cordata*) or flowers (*Musa balbisiana*) were used raw, mostly in salads. Other species were reported to be boiled (*Centella asiatica, Oxalis corniculata, Clerodendrum sp., Nasturtium* sp.) or cooked in soups *(Melientha suavis, Strophioblachia fimbricalyx, Crassocephalum crepidioides). Piper lolot* leaves and fruits of *Canarium album* are cooked with meat, while young fronds of *Diplazium esculentum* are stir-fried with eggs. The big flowers of *Oroxylum indicum* are fried in oil. The leaves of *Ficus racemosa* were used not only in salads but also as spring rolls. The rice powder is left to slightly ferment with pork skin for 5 hours, then they are rolled in the leaves and often eaten with rice wine. The tree can even bear leaves during the whole year and offer food. Young and tender leaves and shoots were preferred over older ones.

Most of these species are commonly used as vegetables and these results highly correspond to ethnobotanical studies from Vietnam (Ogle et al. 2003; Hoang et al. 2008a; Sang et al. 2012).

6.3.3. Preserves

Măng ớt is a typical food of Lạng Sơn province, very popular and commonly prepared in HLNR. It consists of bamboo shoots, garlic, chili and *Clausena indica* fruits, all soaked in salty brine. It is regularly eaten as a condiment with noodles for breakfast. The taste is a combination of sour, spicy and crunchy texture and this type of preparation preserves the food for extended periods of time. Usually, it is prepared in a large glass or plastic containers as could be seen in Figure III (Appendix 2). The use of *C. indica* is not very well described in literature, but *C. lansium* is used in preserves in China (Lim 2012). Another type of preparation was reported from fruits of *Ficus racemosa,* eaten with vegetable or crab soup. They were cut in half and mixed with lemongrass in a salt solution. *F. racemosa* is used in pickles also in Cat Tien Biosphere Reserve (Southern Vietnam). Ripe or unripe syconia, the special type of Ficus fruits, are commonly consumed fresh or also in various types of preserves and side dishes, jams, jellies (Dhyani & Khali 1993; Lansky & Paavilainen 2011; Shi et al. 2014).

6.3.4. Culinary herbs

Eryngium foetidum, Piper lolot and Nasturtium sp. are used as fresh culinary herbs and they are commonly used in tropics (Paul et al. 2011). *Clausena indica* leaves are cooked with pork meat, however, leaves of *C. indica* were never reported to be used for cooking. The use of *C. indica* leaves is not described in the scientific literature. However, the use of leaves of some other *Clausena* species is documented, as e.g. *C. excavata* that is cooked and eaten as a potherb in India due to a characteristic, curry-like smell (Arbab et al. 2012) or *C. anisum-olens* that is used for local dishes and beverages in Philippines (Oyen & Nguyen 1999).

6.3.5. Souring agents

A special category of flavourings are plants that are used as souring agents. Fresh fruits of species such as *Dracontomelon duperreanum*, *Spondias lakonensis*, *Mangifera* sp., 'Hồng tháp', dried fruit skin of *Garcinia* sp. or leaves of *Aganonerion polymorphum*

are utilized for their sour taste. They are added at the end of cooking, typically to fish soups. *Canh Chua Lá Giang Nấu Cá* is a variation of popular traditional Vietnamese fish soup where *A. polymorphum* is an important ingredient (Nguyen 2007a). The sour macerate of *A. polymorphum* was reported to be utilized also in the process of tofu preparation as natural coagulant. The unripe mango fruits are used in sour fish soup also in Yên Châu (Northwest Vietnam), according to Hue et al. (2004).

In contrast with the importance of this group of species to the Vietnamese cuisine, this category is missing in other ethnobotanical studies from Vietnam.

6.3.6. Beverages

Various types of beverages are prepared too. A non-alcoholic drink is made from *Centella asiatica,* aerial parts are mixed with water. *C. asiatica* is commonly consumed in Vietnam and South East Asia, moreover also for its significant medicinal properties (Brinkhaus et al. 2000). *S. lakonensis* or D*. duperreanum* fruits are served soaked in water with sugar as a refreshing drink (Figure III, Appendix II). This type of drinks called 'nước sấu' is prepared from *Dracontomelon* spp. elsewhere in Vietnam too. Alcoholic drinks are prepared from *Musa balbisiana, Pandanus urophyllus* or mature fruits of *Vitis* sp. They are soaked in strong alcohol and drank as local "wine" (Figure III).

Ethnobotanical studies showed the use of *Pandanus* spp. is mostly for handicrafts. For culinary purposes the leaves of *P. amaryllifolius* are preferred (Wardah 2009). Even though fruits of several Pandanus species are edible or used as medicine (Miller 1965; Rohman & Windarsih 2017), there is no information on use for alcoholic or non-alcoholic drinks.

Interestingly, the sap of *Gnetum* sp. was reported as potable and can be used as a source of water in the forest. *Gnetum* is a liana which was described as if once cut into a section of 2 m, it will let run out approximately 1 liter of a sap. Some other species of *Gnetum* (*G. gnemon, G. montanum, G. parvifolium, G. urens)* have been reported to have drinkable sap as well (Brown 1920; Fu et al. 1999; DeFilipps et al. 2004). According

to ethnobotanical study by Sang et al. (2012) the drinkable sap of *G. latifolium* is being used in Vietnamese Cat Tien Biosphere Reserve.

6.3.7. Multipurpose species

Apart of the dietary contribution of edible wild plants, some of the plants are also reportedly used for medicinal purposes (*Saurauia tristyla, Erythropalum scandens, Oroxylum indicum, Rhodomyrtus tomentosa, F. virosa, Strophioblachia fimbricalyx, Flacourtia indica, Ficus racemosa, F. auriculata, Amomum* sp.), a feed for animals (*F. racemosa, Musa* sp.), timber for construction (*Garcinia* sp. *Brucea javanica, Camellia* sp. *Xerospermum noronhianum, Clausena indica*, 'Lâu', 'Cận', 'Lồm côm') or firewood (*C. indica, C. lansium, X. noronhianum, Camellia* sp.*,* 'Lọong', 'Vong'). Leaves of 'Hồng tháp' were described to be used for packaging.

This multipurposeness is well documented in other ethnobotanical studies. Typically, edible species are most commonly used as medicine as well (Ogle et al. 2003; Suksri et al. 2005; Sujarwo et al. 2015).

6.4. Quantitative ethnobotany

Analysing the Frequency of Citation (FC) and the Relative Frequency of Citation (RFC) the most cited species were determined. Although, the RFC index directly depends on the number of informants mentioning a use of a plant (FC). Thirty-nine ethnospecies (67%) were mentioned by at least 2 respondents (FC>1). *Camellia* sp. is the most frequently quoted wild food species, ranked with the highest value of RFC first (RFC = 0.96), followed by *Xerospermum noronhianum* (RFC = 0.82) and '*Vong'* (RFC = 0.67). Consecutive frequently mentioned species is *Melientha suavis* (RFC = 0.53), being the last species mentioned by more than half of informants.

The Smith's Salience (SS) is a more complex index where not only the frequency of citation but also the order of citation of an individual species is evaluated. However, the species with three of the highest scores were the same as previously ($SS_{(Camellia\ sp.)}$ =

0.23; SS $_{(X.\ noronhianum)}$ = 0.18; SS $_{(Vong)}$ = 0.12). This means the species were not only cited by the most informants but were all also recalled among the first. However, these two indices do not consider the use diversity of individual species.

Considering also the use variability of species analysed by the Cultural Value (CV), the highest score reached *Meliantha suavis* (CV = 0.16), then *Camellia* sp. (CV = 0.15), and *X. noronhianum* (CV = 0.11). *Clausena indica* reached its highest position compared to the other indices while *"Vong"* reached its lowest.

The Use Value Index, a commonly used index in ethnobotany was no utilized. The mean of use categories per species is only 1.4 and in this case the Use Values Index copies mostly RFC, because UV index equals to RFC in the case of species with only one use.

Consistent results from indices helped to identify the most preferred, locally important species (see Table 3). Nevertheless, as Hoffman and Gallaher (2007) stress out, the methods used to quantitatively describe the importance of species assume that the citation frequency is "an indicator of importance". Actual uses and cited uses will likely more or less differ and can be influenced by various factors as seasonality, abundance of resources, knowledge loss, age, sex or others.

6.4.1. Culturally most important species and their nutritional aspect

Previously identified group of most prominent species may play the biggest role in nutrition among the local wild plants, and therefore their nutritional content was evaluated. However not all mostly cited species have been analysed. Unfortunately two highly cited ethnospecies 'Vong' and 'Vú sữa bó' were not identified and their nutritional values could not be reviewed. From the highly cited species the nutritional values have not been studied for *Sterculia henryi* (Sterculiaceae), *Spondias lakonensis* (Anacardiaceae) or of an edible fruit of *Camellia* sp. (Theaceae).

Meliantha suavis (Opiliaceae) was a species with the highest cultural value. The fresh shoots and leaves contain per 100 g edible portion: 78.16-82.4% moisture, 6.5-7.4 g protein, 5.5-8.45 g carbohydrates, 0.52 g lipids, 3.4-3.9 g fibre, 1.54-2.2 g ash, 1.6-3.7

mg ß-carotene, 96.2-114 mg Vitamin C, 0.02 mg Vitamin B_1, 7.2 µg Folic acid, 110 mg Calcium, 80 mg Phosphorous and the energy value is about 50 kJ (Khan et al. 2007; Tianpech et al. 2008).

Clausena lansium (Rutaceae) is an evergreen tree native to southern China and Northern Vietnam, cultivated for its yellow edible berry of pleasant taste. The fruits are the largest of the genus (de Bruijn & Schmelzer 2016). The nutrient composition of fruit pulp per 100 g of the edible portion is: 84% moisture, 0.9 g protein, 14.1 g carbohydrates, fat 0.1 g, 0.8 g fibre, 0.9 g ash, ß-carotene equivalent to 0, 148 mg Vitamin C, 0.02 mg Vitamin B_1, 0.11 mg Vitamin B_2, Vitamin B_3 mg, 19 mg Phosphorus, 281 mg Potassium, 15 mg Calcium and traces of Iron. Numerous studies on the phytochemical composition have described bioactive compounds with medicinal properties (Lim 2012 and references therein). *Clausena indica,* equally popular in HLNR is much less researched species. There are no nutritional or phytochemical studies of its fruits available.

Erythropalum scandens is rich in moisture (84.83%) and relatively high in protein (3.7-5.47 g), low in lipids (0.5-0.61 g) and carbohydrates (8 g). Additionally, 100 g of tested leaves contained 7.5 g fibre, 1.1-1.47 g ash, 934 µg Beta-carotene, 4-16.68 mg Vitamin C, 0.08 mg Vitamin B_1, 0.544 mg Vitamin B_2, 121-158 mg Calcium, 1.5-7.28 mg Iron, 120 mg Phosphorous, 1.11 mg Zinc, energy 52 Kcal (per 100 g; Analysed at Food Chemistry Laboratory, Institute of Nutrition Mahidol University, Thailand, May 2005; Vu & Nguyen 2017).

Dimocarpus longan contains in 100 g 78.8-82.9 % moisture, 1.1-1.3 g protein, 0.1 g total lipids, 0.7 g ash, 15.14 g carbohydrate, 0.7-1.1 g fiber, 15.0 µg ß-carotene, 84 mg Vitamin C, 31 µg Vitamin B1, 140 µg Vitamin B2, 0.3 mg Vitamin B3, 1 mg Calcium, 0.13 mg Iron, 266 mg Potassium, 21 mg Phosphorus, Zinc 0.05 mg, 0.052 mg Manganese and 60 kcal of energy (Choo & Yuen 1992; Huang et al. 2010; USDA 2019).

It is worth to note that some other, less cited species are also rich in especially important micronutrients. Rich in Iron are leaves of *Oxalis corniculata* (15 mg; Pal et al. 2015), *Houttuynia cordata* (11.8 mg; Ogle et al. 2001d) and *Centella asiatica* (3.1-4.2

mg). The latter is also a great source of β-carotene (6.58 mg; Brinkhaus et al. 2000; Ogle et al. 2001). Fruits of *Oroxylum indicum* are overall greatly nutritious, but importantly they are a very good source of Zinc (1.6 mg; Mahadkar et al. 2012).

To our knowledge in total twenty-one identified species in this study were subjected to nutritional research to date. Therefore, the nutritional values of numerous species have not been reviewed. The research focus seems to be on pharmacological properties, as most of the species have undergone analysis of bioactive compounds and not on the nutritional potential.

This short review of the chemical compositions and the nutritional values of these few species demonstrates that local wild species are highly nutritive and valuable source of micro and micronutrients for local people in Huu Lien Nature Reserve. However, information on Zinc content, an important element for malnutrition in Vietnam and other countries was often missing. For example, consumption of 100 g per day of leaves of *Erythropalum scandens* provides an amount of Iron almost enough to meet the recommended daily allowance for an adult man.

As discussed previously, particularly the mountainous provinces suffer from malnutrition, however, this study documented high diversity of nutritive food crops available for local communities. Detailed nutritional analyses and phytochemical studies should be carried out to assess the nutritional values of less known but commonly used species in HLNR.

6.5. Famine foods

Survey from 2001 reported periods of food shortage in HLNR (Furey et al. 2002). These “months of hunger” occurred between rice harvests, typically during the months 3-4 and 8 of the Vietnamese Lunar calendar. Local people coped with these periods by selling of livestock to earn money for rice. Another option was collection of wild food in the forest. As discussed before, the importance of WEPs during times of scarcity was documented around world, especially for poor communities (Grivetti & Ogle 2000; Zhang et al. 2016; Pinela et al. 2017).

During the interviews in HLNR, wild plants were described as more important in the past. Life was described as much harder in the past and the reliance on forest resources was stronger. During our survey in 2017, no households, except two, admitted food shortage during year.

Fruits as *X. noronhianum* were mentioned to be used in these periods, but only *Sterculia henryi* was specifically described as famine wild food during rice shortages. The big edible seeds of *Sterculia* are rich in protein (around 20%) and for angiospermous plants are above-average for several essential amino acids (Histidine, Isoleucine, Lysine, Methionine, and Valine). They are also rich in minerals (K, P, Fe, Mn and Cu). The nutritional quality makes them great species to overcome these times of hardship (Idu et al. 2008; Galla & Dubasi 2010; de Britto Policarpi et al. 2018). Nine species from Africa and Asia are included in The Famine Foods Database by Purdue University (www.purdue.edu/hla/sites/famine-foods).

Wild edible plants may remain significant culturally and dietary, but probably due to improved socio-economic situation of local communities, do not have a significant role as famine food anymore in HLNR.

6.6. Domestication and conservation status

Majority of documented species are considered native to Vietnam, often specifically to the area of Southern China and Northern Vietnam, and connected to limestone. *Crassocephalum crepidioides, Eryngium foetidum* and *Oxalis corniculata* originated elsewhere and were naturalized in Southeast Asia.

Two thirds of the recorded plants were sourced only from wild. Twenty species could be also found in homegardens, deliberately brought from forest or naturally grown. It is worth to notice that some species. 'Vong' despite being popular among local people, could not be grown in homegardens due to strong connection to limestone. The collected data on cultivation status were compared to the online version of standard source of cultivated plants - Mansfeld's World Database of Agricultural and Horticultural Crops (Hanelt 2001).

Edible species reported to be exclusively gathered from wild in HLNR and without documented cultivation in other areas were *Saurauia tristyla, Aganonerion polymorphum*, *Dillenia turbinata*, *Strophioblachia fimbricalyx*, *Melastoma septemnervium, Pandanus urophyllus, Glycosmis parviflora*, *Xerospermum noronhianum,* and *Sterculia henryi.*

On the other hand, several species not cultivated in HLNR have been reported to be grown in other areas. *Brucea javanica* was at first cultivated in China, later also in Korea, Japan and Java, now even as ornamental planted in Europe and the USA. *Melientha suavis* is occasionally cultivated in South East Asia. *Musa balbisiana* is being cultivated in Thailand, Malacca, Indonesia, Malayan Peninsula, Philippines, New Guinea. There are known some seedless cultivars. *Flacourtia indica* can be found cultivated nearly everywhere in the tropics of the Old World. *Flueggea virosa* and *Crassocephalum crepidioides* are cultivated in Africa and *Diplazium esculentum* in Bangladesh or in Hawaii by Filipinos.

Species that were reported to be cultivated in homegardens in HLNR, were mostly documented to be cultivated in other countries as well. *Clausena lansium* in contrast to *Clausena indica* has a history of cultivation in Vietnam and China, but also to limited extent in other SE Asian countries, Hawaii and Australia. About eight cultivars are known from China (de Bruijn & Schmelzer 2016). *Melientha suavis* is intercropped in fruit orchards on a commercial scale in northern Thailand. Other species commonly grown in tropics are *Oxalis corniculata, Piper lolot, Dimocarpus longan, Rhodomyrtus tomentosa*, *Syzygium samarangense, Houttuynia cordata* or *Centella asiatica.*

Selling of wild species was not very common in contrast with other studies from Vietnam and Asia (You-Kai et al. 2004; Delang, 2005; Hoang et al. 2008a; Bhatt et al. 2009; Pinela et al. 2017). Even though several informants mentioned occasionally selling specific species (see chapter Results), it was to a very small extent and it did not provide significant part of their income. Overall, wild food plants were not considered of great economic value. Also, species cultivated in homegardens were grown for personal use. However, this review showed that many popular species in HLNR are being cultivated elsewhere in the world and some of them are even grown commercially. Local species

from HLNR have high potential to be used more intensively as well. Further research should be conducted on native species that have potential for cultivation and domestication, e.g. *X. noronhianum, Clausena* spp.

The conservation status of recorded species was reviewed in the Red List of Vietnam (Nguyen 2007b) and in the IUCN List of threatened species (www.iucnredlist.org). *Dimocarpus longan* is classified as near threatened globally. Another species, *Melientha suavis* is on the Red List of Vietnam 2007. This species is sought not only for edible leaves but also for its fruits. At the same, *M. suavis* is one of the most cited species and it is probably often collected. The use of these plants should be acknowledged and taken in consideration in the management of the Reserve.

Larger problem is probably illegal logging. Several local valuable timber species sought by local people as *Chukrasia tabularis* (VU), *Burretiodendron hsienmu* (EN) and *Fernnadoa collignonii* (EN), are globally threatened. Logging in HLNR is not permitted, however, there is relatively recent documentation of *B. hsienmu* to be logged openly (Pham 2011). *C. tonkinensis* (CR) used to be was dominant closed canopy species in the past but was unsustainably exploited for timber and essential oils that lead near to extinction in wild. Illegal logging affected also the availability of edible food. Informants commonly reported that the abundancy of edible species decreased over past decades. The variety of species used to be higher as well. It was easier to collect many fruits, but because of unsustainable logging many edible trees have disappeared. After the large and valuable timber trees were cut down, less valuable species were logged, including many edible ones. Species commonly found in the past in lower, accessible areas, were stated to be found only deep in the forest mountains nowadays. The decrease of abundancy and lower accessibility was repeatedly mentioned for following species: *X. noronhianum, B. javanica, Camellia* sp.*, Garcinia* sp. *and 'Vong'.*

7. Conclusion

This study has documented 58 ethnospecies used as food in Huu Lien Nature Reserve, belonging into 42 genera and 32 families. The complex information recorded included the local name of plant species, genera, family, habit, edible parts, mode of preparation and use, additional uses, domestication and conservation status.

Most cited plants were woody species, trees and shrubs. Especially rich diversity of edible fruits was documented. Informants reported to use the local wild plants as snacks, vegetables, ingredients for alcoholic or non-alcoholic drinks, seasoning, souring agents or condiments.

The culturally most valuable species scoring the highest values from Cultural Value Index are *Meliantha suavis, Camellia* sp. and *Xerospermum noronhianum.* These species were also mentioned among the first and ranked the highest for the Salience index as well.

In general, our study revealed that the Nature Reserve is a repository of rich ethnobotanical knowledge. The wild plants are commonly used, they are part of the local diet and people possess considerable knowledge.

Several species have not been thoroughly studied and provide an opportunity for further research in nutritional or medicinal properties. Species as *Sterculia henryi, Pandanus urophyllus* and *Dillenia turbinata* were documented as edible for the first time.

On the other hands, the nutritional review of the preferred plants showed quality nutritional content and that wild plants can be valuable source of nutrition in Vietnam. Local species can be especially great sources of the important micronutrients for malnutrition in Vietnam. *C. lansium* and *M. suavis* are rich in Vitamin C, *E. scandens, H. cordata* and *O. corniculata* are relatively high in Iron content, while O. indicum is good source of Zinc. However, no nutritional study has been done on around one third of the identified species. Considering the popularity and still present relatively high consumption of wild plants, more attention should be directed to the nutritional value and contributions to diets.

As commonly described in other studies, apart the edible use, the recorded species were also utilized for medicine, feed for animals, as source of fuel or construction wood.

The limitation of this study is considerable number of plants that could not be identified down to species. A second visit in different season would be helpful as many species were not bearing flowers or fruits. Also, it would be beneficial for the study to analyse the nutritive values from local samples to get accurate information valid for Huu Lien Nature Reserve.

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Appendices

List of the Appendices:

Appendix 1: Table 4 List of species with values of calculated indices

Appendix 2: Photographic documentation

Appendix 1

Table 4. List of species with values of calculated indices

SPECIES	VERNACULAR NAME	FC[1]	UR[2]	NU[3]	RFC[4]	SS[5]	CV[6]
Camellia sp.	Chà	47	47	1	0.96	0.857	0.1533
Xerospermum noronhianum Blume	Ké	40	40	1	0.82	0.707	0.1111
Unidentified	Vong	33	33	1	0.67	0.487	0.0756
Melientha suavis Pierre	Rau ngót rừng	26	44	2	0.53	0.219	0.1588
Erythropalum scandens Blume	Bầu bí chai	20	22	1	0.41	0.194	0.0305
Clausena indica (Dalzell) Oliv.	Mắc mật	17	23	3	0.35	0.161	0.0814
Clausena lansium (Lour.) Skeels	Mắc mật rừng	16	18	1	0.33	0.164	0.0200
Vitis sp.	Nho rừng	15	21	2	0.31	0.167	0.0437
Sterculia henryi Hemsl.	Ngoang	12	14	2	0.24	0.129	0.0233
Dimocarpus longan Lour.	Nhãn rừng	11	11	1	0.22	0.139	0.0084
Unidentified	Vú sữa bó	11	11	1	0.22	0.109	0.0084
Diplazium esculentum (Retz.) Sw.	Rau dớn	9	9	1	0.18	0.061	0.0056
Spondias lakonensis Pierre.	Da	8	10	3	0.16	0.063	0.0167
Ficus auriculata	Vả	6	9	2	0.12	0.062	0.0075
Canarium album (Lour.) DC.	Trám	5	8	2	0.10	0.047	0.0056
Dracontomelon duperreanum Pierre	Sấu rừng	4	8	3	0.08	0.023	0.0067
Mangifera sp.	Xoài rừng	4	6	2	0.08	0.041	0.0033
Crassocephalum crepidioides (Benth.) S. Moore	Rau tàu bay	4	4	1	0.08	0.024	0.0011
Gnetum sp.	Gấm	4	5	2	0.08	0.034	0.0028
Ficus racemosa L.	Sung	4	9	3	0.08	0.052	0.0075

SPECIES	VERNACULAR NAME	FC[1]	UR[2]	NU[3]	RFC[4]	SS[5]	CV[6]
Houttuynia cordata Thunb.	Diếp Cá	4	4	1	0.08	0.022	0.0011
Saurauia tristyla DC.	Nhàu	3	3	1	0.06	0.029	0.0006
Centella asiatica (L.) Urb.	Rau má	3	4	2	0.06	0.024	0.0017
Garcinia sp.	Quả Bứa	3	5	2	0.06	0.040	0.0021
Flueggea virosa (Roxb. ex Willd.) Royle	Quả nổ	3	3	1	0.06	0.021	0.0006
Musa balbisiana Colla	Chuối rừng	3	4	2	0.06	0.008	0.0017
Oxalis corniculata L.	Chua me	3	4	1	0.06	0.022	0.0008
Piper lolot C. DC.	Lá lốt	3	5	2	0.06	0.017	0.0021
Rubus sp.	Dum thuốc	3	3	1	0.06	0.029	0.0006
Eryngium foetidum L.	Mùi tàu	2	4	2	0.04	0.004	0.0011
Aganonerion polymorphum Pierre. ex Spire	Chúa lam	2	2	1	0.04	0.011	0.0003
Nasturtium sp.	Cái xoong	2	3	2	0.04	0.016	0.0008
Dioscorea sp.	Củ mài	2	2	1	0.04	0.016	0.0003
Clerodendrum sp.	Bọ mẩy	2	2	1	0.04	0.003	0.0003
Ficus hirta Vahl	Ngái	2	2	1	0.04	0.026	0.0003
Rhodomyrtus tomentosa (Ait.) Hassk.	Sim	2	2	1	0.04	0.021	0.0003
Pandanus urophyllus Hance	Dứa rừng	2	3	1	0.04	0.008	0.0004
Unidentified	Lọong	2	2	1	0.04	0.033	0.0003
Unidentified	Đéo	2	2	1	0.04	0.011	0.0003
Calamus sp.	Quả Mây	1	1	1	0.02	0.005	0.0001
Oroxylum indicum (L.) Kurz	Núc nác	1	1	1	0.02	0.003	0.0001
Dillenia turbinata Fin. & Gagn.	Nọt	1	1	1	0.02	0.017	0.0001
Strophioblachia fimbricalyx Boerb.	Rau Then	1	1	1	0.02	0.003	0.0001

SPECIES	VERNACULAR NAME	FC[1]	UR[2]	NU[3]	RFC[4]	SS[5]	CV[6]
Flacourtia indica (Burm.f.) Merr.	Quanh chau	1	1	1	0.02	0.007	0.0001
Melastoma septemnervium (Lour.) Merr.	Hoa Mua	1	1	1	0.02	0.008	0.0001
Musa sp.	Chuối củ	1	1	1	0.02	0.020	0.0001
Syzygium samarangense (Blume) Merr. &	Quả Roi	1	1	1	0.02	0.010	0.0001
Glycosmis parviflora (Sim.) Little	Bí bung	1	1	1	0.02	0.009	0.0001
Brucea javanica (L.) Merr.	Xoan rừng	1	1	1	0.02	0.015	0.0001
Amomum sp.	Gừng núi	1	1	1	0.02	0.003	0.0001
Unidentified	Hồng tháp	1	2	2	0.02	0.014	0.0003
Unidentified	Lưới chó	1	1	1	0.02	0.012	0.0001
Unidentified	Chà lười	1	1	1	0.02	0.003	0.0001
Unidentified	Cận	1	1	1	0.02	0.012	0.0001
Unidentified	Lâu	1	1	1	0.02	0.012	0.0001
Unidentified	Lồm côm	1	1	1	0.02	0.015	0.0001
Unidentified	Dai	1	1	1	0.02	0.011	0.0001
Unidentified	Tac	1	1	1	0.02	0.003	0.0001

[1]FC (Frequency of Citation); [2]UR (Use Reports); [3]NU (Number of Use Categories); [4]RFC (Relative Frequency of Citation); [5]SS (Smith's Salience), [6]CV (Cultural Value Index)

Appendix 2: Photographic documentation

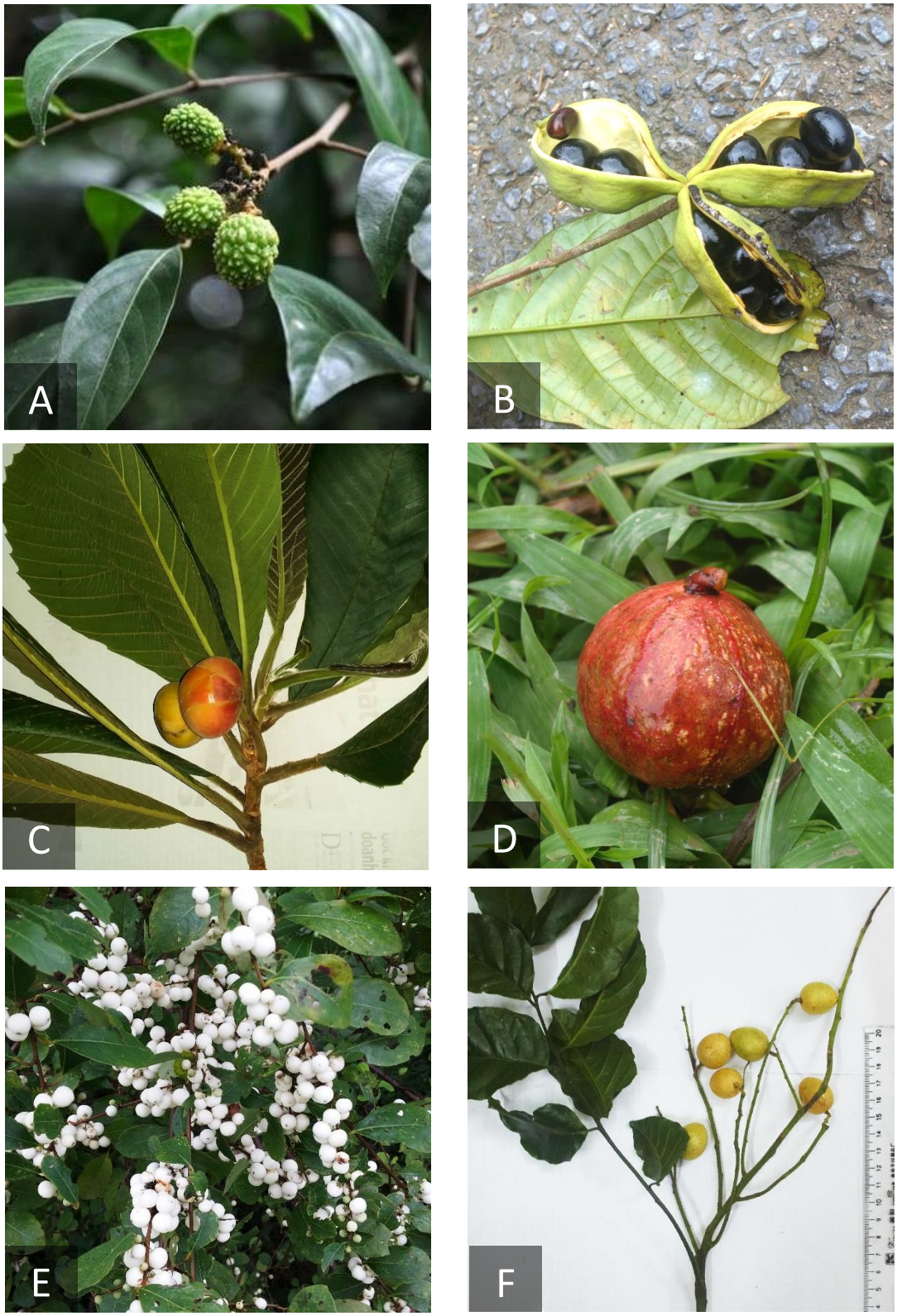

Figure I Some examples of wild species with edible fruits traditionally used in the Huu Lien Nature Reserve, Lạng Sơn province, Vietnam. A: *Xerospermum noronhianum* (photograph by Mr. Hung, Dept. of Conservation, HLNR) B: *Sterculia henryi* C: *Dillenia turbinata* D: *Ficus auriculata* E: *Flueggea virosa* F: *Clausena* sp.

Figure II. *D. esculentum* at the local market and boiled as a meal

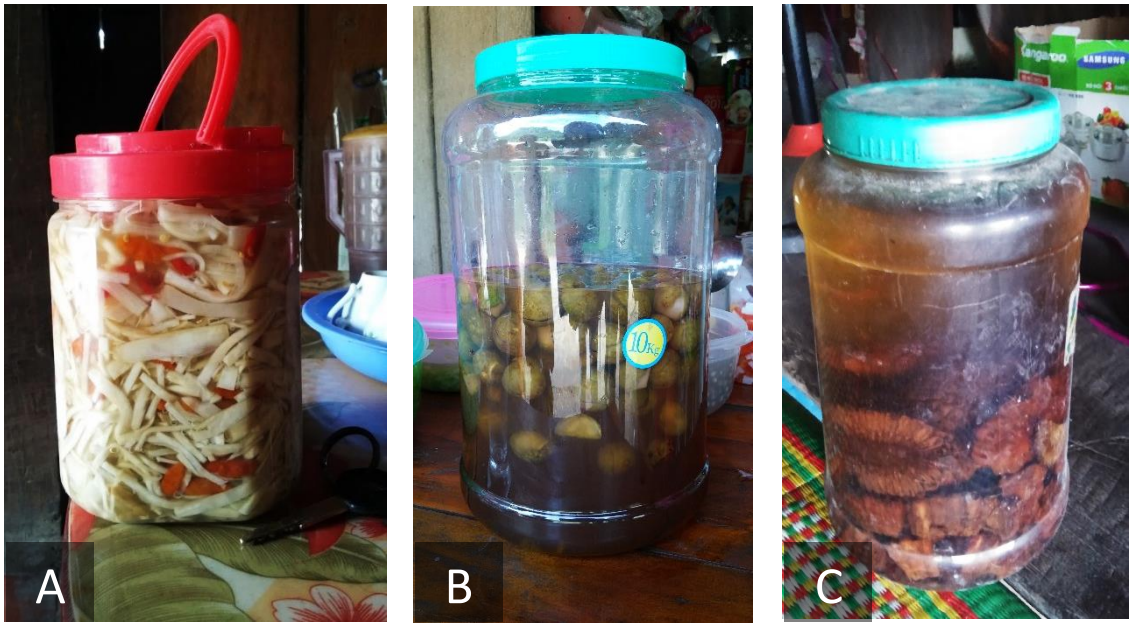

Figure III Various food products from local wild plants A: Măng ớt **B**: Non-alcoholic drink from *Dracontomelon* fruits **C:** Home-made alcoholic drink with *Pandanus* sp.

Figure IV. Ornamental roof construction made from *X. noronhianum*

Figure V. Local guides snacking on *Clausena* sp.

Figure VI. Local Dao women

"Burning the forest is like burning our home,
Burning the forest is like burning our skin and our flesh."

Figure VII. Typical landscape of karst towers and flat valley in the middle of the Reserve