

Wild edible herbs in paddy fields and their sale in a mixture in Houaphan Province, the Lao People's Democratic Republic

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Abstract

Multiple wild edible herbs coexist in paddy fields under the agricultural practices used for growing rice. Paddy field vegetation was surveyed and the rural population's perceptions and use of wild edible herbs were investigated in the northern Lao People's Democratic Republic. A total of 115 wild herbaceous species were observed in the paddy fields of two villages; 52 species grew in fields, 95 on levees, and 63 on banks. Of these, 25 species were locally used, and 22 were sold as *a mixture* at the Xamneua market, with species composition varying by availability and season. The total number of edible greens increased during the summer season when available vegetables were scarce. *Marsilea quadrifolia* L. (Marsileaceae), the most abundant in the field and in the market, as well as *Centella asiatica* (L.) Urb. (Apiaceae), *Eryngium foetidum* L. (Apiaceae), *Spilanthes oleracea* L. (Asteraceae), and *Monochoria hastata* (L.) Solms (Pontederiaceae) were the most popular wild herbs sold. Wild edible herbs are called “phak”, which is also used to indicate cultivated vegetables, and clearly distinguishes them from the inedible herbs referred to as “nya”. Two methods are employed to gather wild edible herbs: some plants are uprooted as a way of thinning individuals, and other plants have only their young leaves picked so that they can be harvested repeatedly. Gathering and selling wild edible herbs was mainly conducted by women and children

for whom it was a source of cash income. Thus, the relationships that exist between people and the wild plants they maintain as part of their farming activities can be considered an indicator of paddy field agrobiodiversity.

Key words: agrobiodiversity, local market, non-weed plant, paddy rice farming, wild food source, Xamneua

Introduction

Although paddy rice fields are primarily used as agricultural land for staple crop production, they also harbor a diversity of organisms. Wild plants as well as insects, birds, and aquatic animals are important components of the paddy field ecosystem (Heckman 1974). However, modern agronomy defines wild plants as weeds and improved agricultural practices have eliminated various wild plants from paddy fields through advances in drainage and irrigation systems, reinforced concrete levees and banks, and the use of herbicides (Shimoda 2003). As a result, in countries such as Japan, many of the wetland plants that previously grew in paddy fields have become endangered species and are now recognized as indicators of environmentally benign agricultural practices. Conversely, a variety of wild plants found in paddy fields are utilized for food, forage, or household purposes in many Asian countries, e.g., in India (Datta and Banerjee 1978), Indonesia (Soerjani et al. 1987), and Thailand (Cruz-Garcia and Price 2011).

This study was conducted in paddy rice farming communities in the Lao PDR, where the rural population does not use herbicides and gathers various wild edible herbs in paddy fields for daily use. Diverse wild herbaceous plants, including rare species, grow

in these paddy fields and some of them are used as food, medicine, or materials for handicrafts in the central Lao PDR (Kosaka et al. 2006). In northeast Thailand, where the vegetation and local culture are similar to those in the central Lao PDR, wild plants found in paddy fields accounted for a large proportion of the edible wild greens that were gathered by farmers (Moreno-Black et al. 1996; Price 1997). Importantly, these plants were not only consumed by the people who harvested them, but they were also traded in the local markets (Moreno-Black and Price 1993). Our preliminary field observations in the Lao PDR revealed that the paddy field vegetation in the north of the country differed from that in the central region, and that a mixture of wild edible herbs was sold at the local markets in the north of the country.

This paper focuses on a study that was conducted in the northern Lao PDR to answer the following key questions: (1) what kinds of wild herbs are grown in paddy fields, (2) how does the rural population gather, use, and identify the wild edible herbs that grow in their paddy fields, and (3) why are mixtures of wild edible herbs sold at markets. Specifically, we sought to examine the agrodiversity (Brookfield 2003) of paddy fields, which is a significant component of human–plant relationships that differs from the traditional dependence of humans on monocultures of staple crops.

Study site and methods

Study site

The Lao People's Democratic Republic (the Lao PDR) is a landlocked country in mainland Southeast Asia with an area of 236,800 km² (Fig. 1). Of the approximately 5.3 million people in the country, 80% live in rural areas (ADB and UNEP 2004). A variety of wild plant resources are used daily for food, medicine, fuel, fiber, oil and resins, and

as materials for handicrafts (Greijmans et al. 2007). Field surveys were conducted in Xamneua District, the provincial capital of the Houaphan Province, which has an area of 16,500 km² and a population of 322,200, and is located in the northeastern Lao PDR adjacent to Vietnam (Fig. 1). The total area under rice cultivation in the province was 26,323 ha in 2005, which consisted of 11,485 ha (43.6%) of paddy rice fields (lowland rice fields in the monsoon season), 13,570 ha (51.6%) of swidden fields (upland rice fields), and 1,268 ha (4.8%) of lowland rice fields irrigated in the summer season (MAF 2006). The Xamneua District is located in the central part of the province and is home to 46,800 people, including the Lao, Tai Leu, Tai Dam, Tai Deng, Khmu, and Hmong communities. Paddy rice fields are located in valleys, whereas swidden cultivation is conducted on the mountain slope. There are three seasons per year: a warm and dry summer (March - April), a monsoon season (May - October), and a cool and dry winter (November - February). About 85% of annual rainfall (930 mm) occurs during the monsoon season. The mean annual maximum temperature is 19.8°C and the mean annual minimum temperature is 12.1°C (World Weather Online 2013).

The local market at the center of Xamneua city (Fig. 1) opens both in the morning (6:30 - 9:00) and in the evening (15:30 - 18:00). The largest area of the market was occupied by a perishable foods section where more than 50 vendors deal with meat from domestic animals, wild and cultivated freshwater fish and shellfish, seafood imported from Vietnam and Thailand, wild and cultivated leafy vegetables, fruits, and spices, wild edible insects, ready-made dishes and sweets, and natural medicines. The vendors rented space for 250,000 - 300,000 kip per year per space (concrete or wooden table of about 1 m²) and an additional 2000 kip per selling day (1 US\$ = 8005 kip on July 24, 2012). Some vendors specialized in retailing, whereas others gathered, harvested, or

cooked foodstuffs by themselves. The perishable foods section was surrounded by other sections selling clothes and miscellaneous daily goods, and small restaurants.

Xamneua village and Nasakang village, located about 1 km from the Xamneua market at an altitude of 1200 m, were selected for the following field surveys (Fig. 1). Both villages were established in the 1970s by the local Lao people and Lao, Tai Dam, Khmu, and Hmong immigrants. About 70% of the households were engaged in paddy rice cultivation, but some new immigrants did not have their own fields. Paddy rice fields in this area were located in the riverside lowland and on the river terrace (Fig. 1) and were irrigated through a small-scale canal system from a dam upstream. The most popular rice variety cultivated was “Khao Kai Nooi Leuang”, a member of the photo-sensitive sticky rice variety group called “Khao Kai Nooi” for monsoon-season cropping. Seeding was conducted in May, transplanting in June, and harvesting in November. The average yield of paddy rice was 2 - 3 t/ha. Overgrown wild plants on levees were cut using a long-handled machete called a “pha” 2-3 times a cropping season. Unwanted plants in fields were manually removed and either buried in the field or piled up on the levee when they were too numerous. Herbicides, pesticides, and chemical fertilizers were not applied. Wild fish, snails, crabs, shrimp, and water insects were also gathered in the fields. Some people grew tilapia fish (*Oreochromis niloticus*) by releasing young individuals in the fields.

Methods

The local market at the center of Xamneua city (Fig. 1) was visited a total of ten times from the first visit in August 2005 to the last in July 2012. Useful plants sold at the market were recorded for 3 days per visit in the summer (March), monsoon season (May,

June, July, August), and winter (November). The local name, domestication status (cultivated, transplanted, or wild), habitat, use, and price for respective plants were documented in the morning and evening, and specimens were collected. More than ten vendors were interviewed per day. This paper focuses on the wild edible herbs gathered in paddy fields and sold in a mixture. The species composition of the mixture of herbs they sold was recorded on March 2 - 4, March 25 - 27, May 2 - 4, July 2 - 4, July 27 - 29, and November 16 - 18. The relative abundance of each species in the mixture was determined by visual assessment of its relative volume (%) with 5 - 10 replicates in each survey period. To evaluate seasonal differences in mixtures, a non-metric multidimensional scaling ordination was conducted for the species composition data using the Bray-Curtis distance index by PC-ORD software package (McCune and Mefford, 2006).

The paddy field vegetation was surveyed in the summer (March 25-26, 2012) and monsoon season (July 27-28, 2012) at Xamneua village and Nasakang village (Fig. 1). The survey method differed with different habitats of the paddy fields (Fig. 2). Twenty fields in both villages were selected as field plots to cover different vegetation types according to preliminary observations (Fig. 1). Plot areas ranged from about 25 to 400 m². The quadrat method was used to determine the composition and coverage (%) of wild herbaceous plants (spermatophytes and pteridophytes) in each field plot. Four quadrats (1 m by 1 m) per plot were established and mean species' coverage was calculated per plot. The importance of each species was estimated using an index of specific value (ISV; Pinder and Rosso 1998); species with a value > 0.2 were considered dominant species (Tomita et al. 2003; Kosaka et al. 2006). For wild herbaceous plants (spermatophytes and pteridophytes) on levees and banks, the structure of the various

microhabitats (i.e., shore, flat part, and grassland as defined by Yamaguchi and Umemoto 1996) prevented us from establishing quadrats (Fig. 2; Kosaka et al. 2006). Therefore, transects were established for the levees of the field plots (each transect was 5-20 m long and 0.2-0.4 m wide, with four transects per field plot) and at the banks of the irrigation ditch (each transect was 5 m long and 0.3-1 m wide, with two transects per bank and near the respective field plots). Then the abundance of wild plants was recorded using a qualitative scale (Pauchard and Alaback 2004): A, abundant (present along >25% of the transect length); C, common (10-25%); I, intermittent (<10%); and R, rare, when only one group of individuals was present. The nomenclature for the sampled plants followed Harada et al. (1993), Ho (1999-2000), Santisuk and Larsen (1997-2012), and Smitinand and Larsen (1970-1996). Voucher specimens are lodged in the herbarium of the Faculty of Forestry, the National University of the Lao PDR.

In June 2010 and March and July 2012, more than 20 local farmers were interviewed in the Lao language at paddy fields or field huts regarding the local name, use, and their perception of wild herbaceous plants, rice cropping techniques, and plants harmful to rice production in the Xamneua village and Nasakang village. Cropping and gathering activities as well as the growth of rice plants were also observed during the survey periods.

Results

Floristic characteristics of wild herbs in paddy fields

One hundred fifteen wild herbaceous species, representing 86 genera and 37 families, were recorded from fields, levees and banks of Xamneua village and Nasakang village (Table 1).

Among these, 52 wild herbaceous species, representing 42 genera and 25 families, were recorded in fields (Fig. 3A). *Rotala rotundifolia* (Buch.-Ham. ex Roxb.) Koehne (Lythraceae), *Marsilea quadrifolia*, *Digitaria* sp. in the summer, and *Marsilea quadrifolia* were the dominant species in the monsoon season (ISV > 0.2). Asteraceae (4 spp.) and Poaceae (4 spp.), and Cyperaceae (7 spp.) and Poaceae (7 spp.) were the dominant families in the summer and monsoon season, respectively (Table 1).

Ninety-five wild herbaceous species, representing 71 genera and 28 families, were recorded on levees (Fig. 3B). The most abundant species on levees in the summer was *Ageratum conyzoides* L. (Asteraceae), and in the monsoon season, *Ageratum conyzoides*, *Kyllinga brevifolia* Rottb. (Cyperaceae), and *Paspalum conjugatum* P. J. Bergius (Poaceae) were dominant. Asteraceae (12 spp.) and Poaceae (9 spp.), and Poaceae (15 spp.) and Asteraceae (11 spp.) were the dominant families in the summer and monsoon seasons, respectively (Table 1).

Sixty-three wild herbaceous species, representing 50 genera and 21 families, were recorded on the banks. *Bidens pilosa* L. (Asteraceae), *Leersia hexandra* Swartz (Poaceae), and *Paspalum conjugatum* were the abundant species on banks both in the summer and monsoon seasons. Asteraceae (10 spp.) and Poaceae (7 spp.), and Asteraceae (11 spp.) and Poaceae (10 spp.) were the dominant families in the summer and monsoon season, respectively (Table 1).

Gathering, use, and perception of wild herbs in paddy fields

Gathering of wild edible herbs in paddy fields was mainly conducted by women and children during agricultural activities or on the way to and from the fields. Wild edible herbs were also gathered from paddy fields beside houses before cooking in the

morning and evening. Villagers were allowed to gather herbs everywhere and at all times within their village area. Villagers knew the places where wild edible herbs were abundant, especially the perennials such as *Centella asiatica*, *Marsilea quadrifolia*, and *Houttuynia cordata* Thunb. Some edible herbs (Table 1) were gathered for both selling and consumption by the harvesters, while other herbs, such as the leafstalks of *Colocasia esculenta* (L.) Schott (Araceae, “phak boon”) or the young leaves of *Hydrocotyle vulgaris* L. (Araliaceae, “phak nook vian”), were only for consumption by the person harvesting the herbs.

Two methods were used to gather herbs: picking the young leaves with a small knife, and uprooting the whole plant manually. *Marsilea quadrifolia* was gathered in both ways, whereas *Centella asiatica* was often uprooted together with its creeping stems. All of the gathered herbs, regardless of the species, were collected for transport in the same rattan basket on the waist or in a plastic hand basket (Fig. 3C). *Ipomoea aquatica* Forssk. (Convolvulaceae), one of the most popular and widely cultivated vegetables, was gathered only for consumption by the harvester because it was scarce in the wild at this study site.

Wild edible herbs are referred to using the Lao term “phak”, which also be used to refer to cultivated vegetables (Table 1). Wild inedible herbs are called “nya,” which include the herbs that are used as fodder for livestock. *Ludwigia adscendens* (L.) H. Hara (Onagraceae, “nya poot”) and *Echinochloa crus-galli* (L.) P. Beauvoir. (Poaceae, “nya wang”) in fields, and *Digitaria* spp. and *Panicum repens* L. (Poaceae, collectively called “nya waay”) and *Paspalum conjugatum* (“nya feet”) on levees, were regarded as the most harmful species to rice production. In July, *Sagittaria trifolia* ssp. *leucopetala* (Miq.) Q.F.Wang (Alismataceae), *Cyperus* spp., *Fimbristylis* spp., *Scirpus* sp., *Blyxa*

aubertii Rich. (Hydrocharitaceae), *Utricularia aurea* Lour. (Lentibulariaceae), *Ludwigia adscendens*, *Ludwigia hyssopifolia* (G.Don) Exell (Onagraceae), *Digitaria* sp., *Echinochloa crus-galli*, *Panicum repens*, *Paspalum* sp., and *Monochoria vaginalis* (Brum.f.) Presl (Pontederiaceae) were manually uprooted from the fields and piled up on the levees (Table 1). Some wild edible herbs, such as *Centella asiatica*, *Marsilea quadrifolia*, *Monochoria hastata*, *Monochoria vaginalis*, and *Houttuynia cordata* were referred to by their common Lao names and others such as *Crassocephalum crepidioides* (Benth.) S. Moore (Asteraceae) and *Pratia nummularia* (Lam.) A. Br. & Aschers. (Campanulaceae) were referred to by more than one local name (Table 1).

A popular local dish called “sup phak” (boiled vegetables) was cooked by boiling the wild herbs collected in the paddy fields. Ginger and salt were added for flavoring and chili powder or sesame was added if desired. Many interviewees mentioned that the mixture of several species enhanced flavor. “Sup phak” was taken as a side dish with steamed sticky rice.

Mixed wild edible herbs of paddy fields sold at the Xamneua market

Wild edible herbs from paddy fields were sold at the Xamneua market, both in the morning and evening (Fig. 3D). The herbs sold in the morning had been gathered the previous evening and the ones sold in the evening had been gathered that afternoon. They were brought from nearby villages, such as Xamneua, Naliu, Phoxay, Thatmuang, Nasakang, and Nathong (Fig. 1). The herbs were washed in water and the roots were removed before being arranged at the selling place. Vendors sold wild herbs that they had collected themselves, or that they were selling on behalf of neighbors, relatives, or other local gatherers that did not have a selling place in the market. On Sundays, some

schoolchildren gathered wild herbs in the afternoon and sold them at their mother's selling space in the market in the evening. There was a case in which a woman gathered 3 kg of *Centella asiatica* in Xamtai (150 km from Xamneua town) and sold them at the selling place of a relative in the Xamneua market. Wild herbs were arranged among cultivated crops in the same selling place. Vendors brought 0.5-3 kg of marketable wild herbs in plastic bags, often as a mixture of several species, and then arranged these herbs in piles in the selling place (Fig. 3E). They occasionally sprinkled water on the herbs to prevent them from withering on hot days. A single bunch of wild edible herbs (100 - 200 g) from the paddy fields was sold at the price of 1000 - 2000 kip. There was no difference in price for bunches of herbs containing a mixture of different species. Buyers with large plastic hand baskets often purchased all of the bunches of herbs arranged in the selling space, which amounted to 500 g - 1 kg. Buyers were typically city dwellers who did not have paddy fields and who worked as civil servants, schoolteachers, and shopkeepers in the Xamneua city.

Table 2 shows the relative abundance of wild edible herbs from paddy fields sold at the Xamneua market. Twenty-two species, representing 21 genera and 16 families, were recorded. Among them, 13 species were annuals and 9 species were perennials; 4 species were hydrophytes, 4 species were hygrophytes, and 14 species were mesophytes. These herbs were mainly gathered on levees (16 species), in fields (8), on banks (5), and in ditches (3) (Fig. 2). *Marsilea quadrifolia* was the most abundant herb sold every season, while *Alternanthera sessilis* (L.) R.Br. ex DC. (Amaranthaceae), *Laphangium luteoalbum* (L.) Tzvelev (Asteraceae), *Nasturtium officinale* W.T. Aiton (Brassicaceae), *Myosoton aquaticum* (L.) Moench (Caryophyllaceae), *Astragalus sinicus* L. (Fabaceae), *Houttuynia cordata*, *Lindernia* sp., and *Viola* sp. were only sold in small amounts. More

species were sold in the summer than in the monsoon and winter seasons. The average number of species in each mixture was eight in the summer, three in the monsoon season, and four in the winter. For example, nine species were sold in a mixture on March 25, 2012 (Fig. 3F). Although there were fewer species in each mixture in the monsoon season, *Centella asiatica*, *Marsilea quadrifolia*, and *Monochoria vaginalis* were often sold separately in large amounts. *Eryngium foetidum*, *Nasturtium officinale*, and *Houttuynia cordata* were often cultivated and were also sold separately in large amounts; however, only those herbs growing in the wild were counted in Table 2. The non-metric multidimensional scaling ordination showed seasonal differences in the species composition of a mixture (Fig. 4). The species composition of the herb mixtures was observed to vary in the summer and during the monsoon. During the summer there was relatively more *Centella asiatica*, *Cyanotis axillaris* (L.) D.Don ex Sweet (Commelinaceae), or *Juncus prismatocarpus* R.Br. (Juncaceae), with the latter containing a relatively high abundance of *Marsilea quadrifolia* or *Monochoria vaginalis*. The winter composition of the herb mixtures was intermediate between the two.

Discussion

Among 115 wild herbaceous species recorded in the paddy fields of this study site, 25 species (22%) were used locally and 22 (19%) were sold at Xamneua market as edible greens (Table 1). The number of wild edible herbs in the paddy fields that were used or sold was larger in this study site than in the surrounding regions; namely, six species were sold at seventeen markets in Vientiane (Fig. 1; Saito et al. 2007), eleven were used and three were sold at two villages in Savannakhet (Fig. 1; Kosaka et al. 2006), and fourteen were used at one village in Kalasin in northeastern Thailand (Fig. 1; Price

1997). *Monochoria vaginalis* was the most common species used in those regions. The use of typical temperate-zone species, such as *Laphangium luteoalbum*, *Pratia nummularia*, *Myosoton aquaticum*, *Juncus prismatocarpus*, and *Viola* sp., was characteristic of this study site.

The importance of wild herbs in agricultural fields has been illustrated in several previous studies. Chacon and Gliessman (1982) showed that wild herbs were classified into “buen monte” (good plants) and “mal monte” (bad plants) in the traditional tropical agroecosystems of Mexico, prompting those authors to propose the “non-weed” concept. The “non-weed” concept can be applied to this case study in the northern Lao PDR. Wild edible herbs and cultivated vegetables were both referred to as “phak” (Table 1), which is the Lao word for vegetable or the prefix for vegetable. “Phak” were clearly differentiated from wild inedible herbs called “nya”. They were not only consumed as vegetables in daily meals, but they were also sold at markets after being arranged equally with the cultivated vegetables in the selling place as a source of cash income (Fig. 3D, 3E).

The sale and use of mixtures of paddy field herbs were widely undertaken at this study site (Fig. 3E, 3F). Bunches of mixed upland field herbs were also sold at Xamneua market (personal observation). On the other hand, wild edible herbs were sold and consumed individually in the central Lao PDR (Kosaka et al. 2006). It was considered that there were three reasons for making mixtures of wild edible herbs. Firstly, wild herbs were inevitably mixed because they were collected and transported in one basket. Secondly, vendors and farmers stated that herb mixtures enhanced the flavor of the local dish “sup phak”. Thirdly, the species composition of these mixed herbs differed according to the season (Fig. 4), with the total number of species in a mixed

bunch increasing in summer (Table 2). The collection and sale of mixed herbs increased the total amount of edible greens; otherwise, the amount of wild herbs and cultivated vegetables would be relatively small in summer. For example, Moreno-Black et al. (1996) and Moreno-Black and Somnasang (2000) showed that wild plants sold at the local markets in northeastern Thailand were most diverse in the summer when other edible vegetables were scarce. In the past in Japan, wild herbs such as *Oenanthe javanica* (Bl.) DC. (Apiaceae), *Artemisia princeps* Pamp. (Asteraceae), *Petasites japonicus* (Siebold & Zucc.) Maxim. (Asteraceae), *Taraxacum* spp., *Capsella bursa-pastoris* (L.) Medik. (Brassicaceae), *Cardamine flexuosa* With. (Brassicaceae), *Stellaria media* (L.) Villars (Caryophyllaceae), *Equisetum arvense* L. (Equisetaceae), *Allium macrostemon* Bunge (Amaryllidaceae), *Plantago asiatica* L. (Plantaginaceae), *Polygonum* sp., and *Viola* sp. were gathered around agricultural fields and streams, and consumed boiled during winter and early spring when other fresh greens were typically scarce (Arioka 2008). Of these species, *Stellaria* sp., *Polygonum* sp., and *Viola* sp. were common at this study site (Table 2).

The following four elements of agrodiversity, namely biophysical diversity, management diversity, agrobiodiversity, and organizational diversity (Brookfield et al. 2003), were examined in line with the findings of this study. Unnecessary wild herbs were selectively removed from paddy fields, which were carefully tilled, leveled, and submerged so that rice could be transplanted to the fields. Levees and banks were regularly repaired and cleaned to keep the field submerged and to serve as walkways. Irrigation and drainage ditches were inevitable for stable rice production and sizable amounts of money and labor were invested for their construction and maintenance. These incessant farming activities created a variety of micro-environments in and

around paddy fields (Fig. 2), which in turn supported a variety of wild herbs (biophysical diversity and agrobiodiversity; Table 1). Gathering wild herbs was not only for acquiring edible greens: uprooting *Centella asiatica*, *Marsilea quadrifolia*, and *Monochoria vaginalis* played a role in thinning the number of wild plants in the fields and levees. Picking only the young leaves of *Houttuynia cordata* allowed its roots to remain intact, which prevented the levees from eroding (management diversity). Gathered wild herbs were sold at local markets and became a source of income for women (Fig. 3D; Moreno-Black and Price 1993). This trend was promoted by the increasing demands of the nonfarming population for chemical-free wild greens and by the subsequent development of trading activities within and among villages (organizational diversity). Thus, a variety of relationships between people and wild plants were maintained in paddy fields that were originally created for the monoculture of rice.

Conclusion

Since the late 1990s in the Lao PDR, intensive rice farming has been promoted near urban areas through the introduction of high-yield rice varieties, large-scale irrigation systems, and agricultural chemicals and fertilizers. On the other hand, rice for self-consumption has been produced without applying agricultural chemicals and fertilizers to the paddy fields at this study site, where manmade habitats harbored a variety of wild herbaceous plants. The rural population referred to wild edible herbs using the same term as that used to refer to cultivated vegetables and clearly distinguished them from inedible herbs. Wild edible herbs were sold in mixed bunches at the local market, arranged in the same way as cultivated vegetables. The reasons for

mixing the herbs were to enhance the flavor of the popular local dish of boiled greens, mixing at the time of collection, and to increase the total amount of edible greens during the summer when the availability of other cultivated vegetables decreases. The relationship between the rural population and wild edible herbs in this study site was a typical case of agrodiversity composed of biophysical diversity, management diversity, agrobiodiversity, and organizational diversity (Brookfield et al. 2003).

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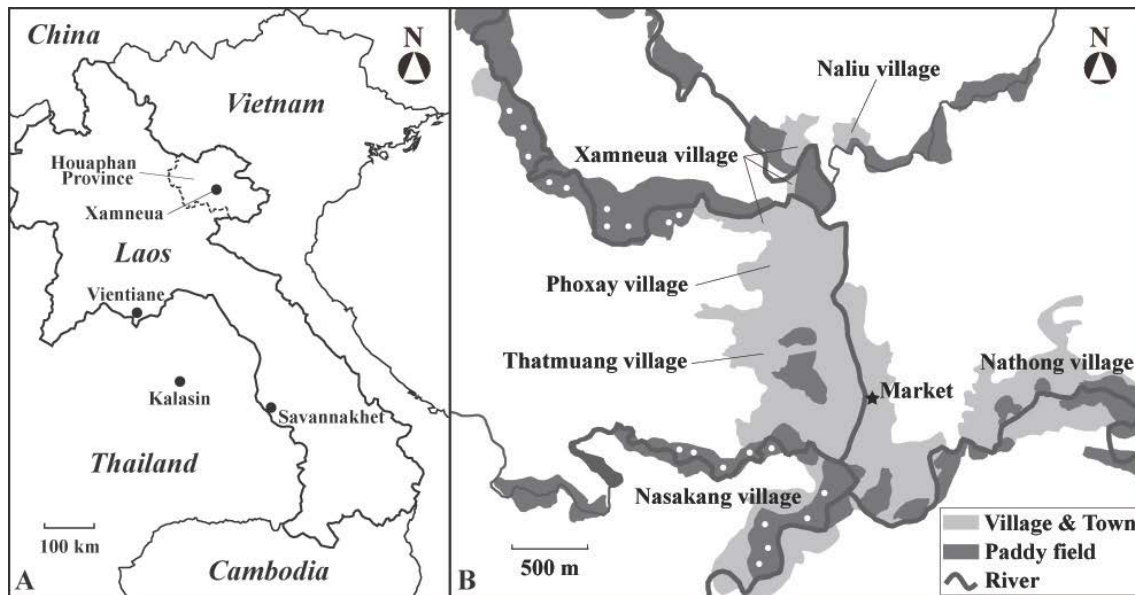


Fig. 1. Location of Xamneua city (A) and map of the study site (B) in Houaphan Province in the Lao PDR. Solid white dots on map (B) indicate the location of field plots.

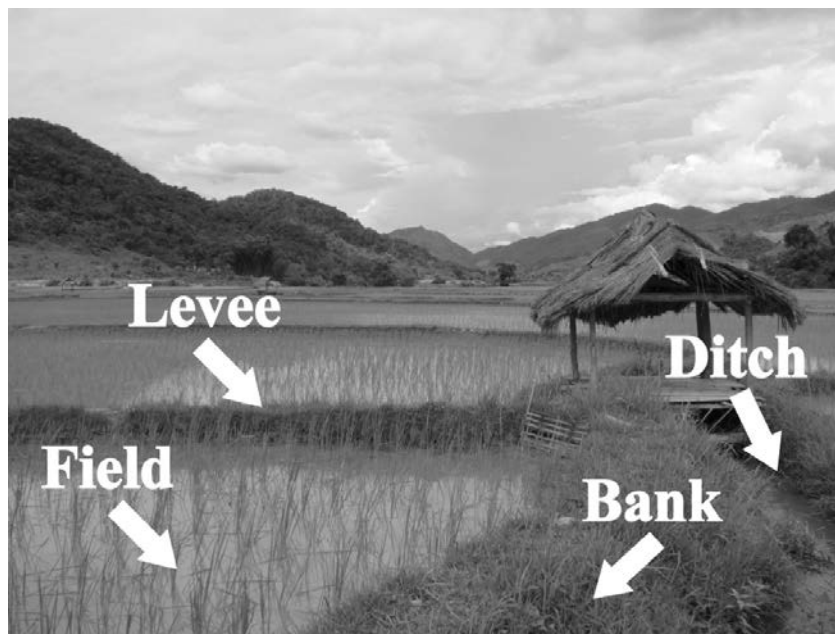


Fig. 2. Different habitats for wild herbaceous plants in paddy fields in Houaphan Province in the Lao PDR.

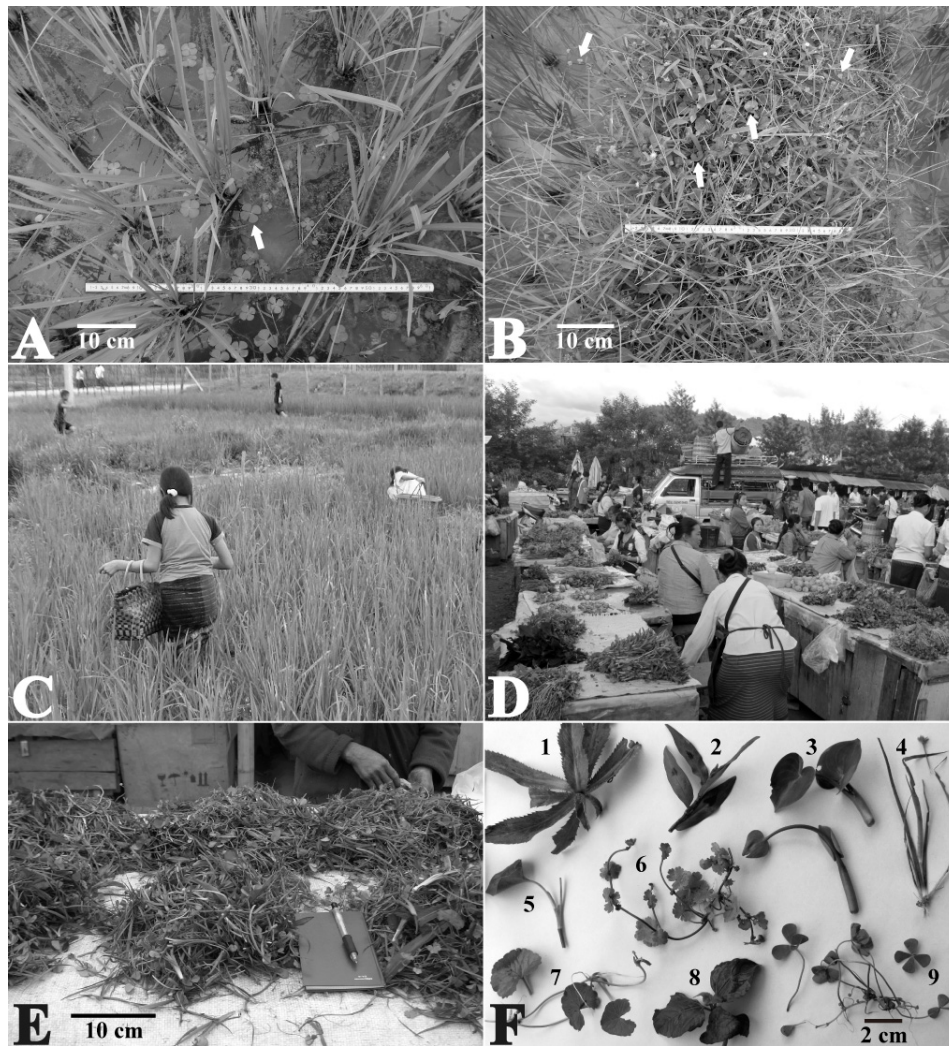


Fig. 3. Wild edible herbs growing in paddy fields and sold at the Xamneua market in Houaphan Province in the Lao PDR: *Marsilea quadrifolia* growing between rice plants in the field (A), *Centella asiatica* (up-arrows) and *Spilanthes oleracea* (down-arrows) on the levee (B), children gathering wild herbs in a paddy field near houses (C), vendors selling fresh vegetables at the Xamneua market (D), bunches of mixed wild edible herbs for sale (E). Contents of a bunch of mixed herbs from a vendor; *Eryngium foetidum*¹, *Polygonum* sp.², *Monochoria hastata*³, *Juncus prismatocarpus*⁴, *Houttuynia cordata*⁵, *Hydrocotyle petelotii*⁶, *Centella asiatica*⁷, *Spilanthes oleracea*⁸, and *Marsilea quadrifolia*⁹ on March 25 (F; Table 2).

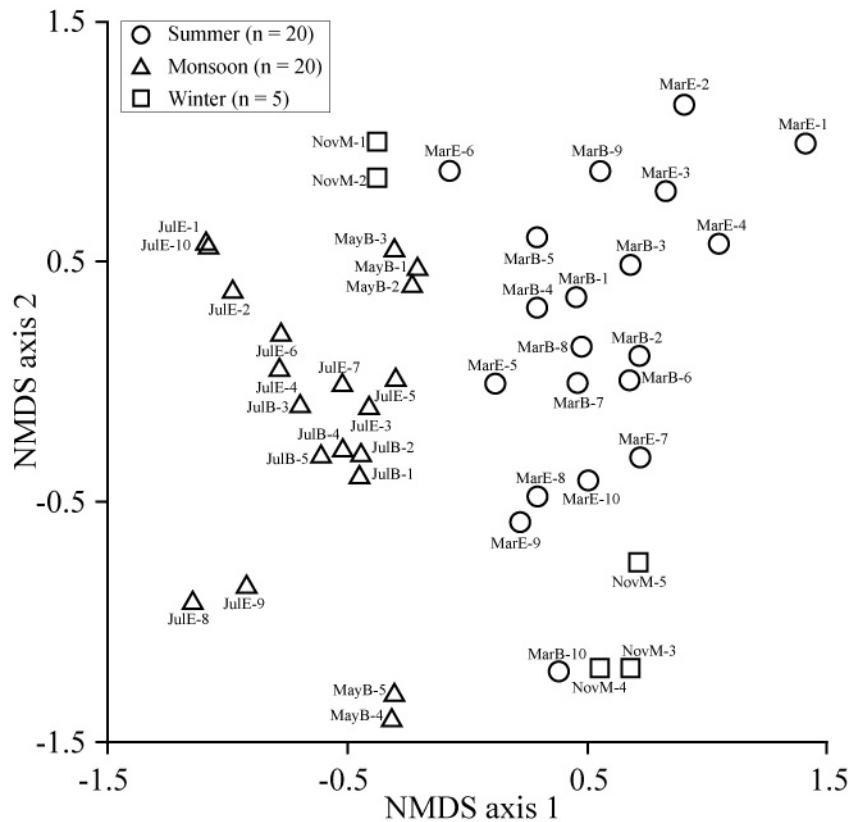


Fig. 4. Non-metric multidimensional scaling ordination of species composition data of mixed wild edible herbs sold at the Xamneua market, Houaphan Province in the Lao PDR (stress = 19.82). MarB, species composition recorded in the beginning of March; MarE, end of March; MayB, beginning of May; JulB, beginning of July; JulE, end of July; NovM, middle of November; numbers after the “-” indicate the number of replicates.

Table 1. Wild herbaceous species in paddy fields at Xamneua village and Nasakang village, Houaphan Province in the Lao PDR.

Scientific name	Family	Life-form	Season ^{a)}	Water ad. ^{b)}	Habitat ^{c)}	Management ^{d)}	Local name
<i>Sagittaria trifolia</i> ssp. <i>leucopetala</i> (Miq.) Q. F. Wang	Alismataceae	Perennial	S, M, (W)	Hydrophyte	Fl	Uprooted	
<i>Alternanthera sessilis</i> (L.) R. Br. ex DC.	Amaranthaceae	Annual	S, M	Hygrophyte	Lv, Fl, Bk	Cut, Picked ^m	Phak Khan Tan
<i>Centella asiatica</i> (L.) Urb.	Apiaceae	Perennial	S, M, W	Mesophyte	Lv*	Uprooted ^m	Phak Nook
<i>Eryngium foetidum</i> L.	Apiaceae	Perennial	S, M, W	Mesophyte	Lv	Picked ^m	Phak Peen Vien
<i>Oenanthe linearis</i> Wall. ex DC.	Apiaceae	Perennial	S, M, (W)	Hygrophyte	Lv, Fl, Bk		
<i>Colocasia esculenta</i> (L.) Schott	Araceae	Perennial	S, M, W	Hygrophyte	Bk*	Picked ^s	Phak Boon
<i>Spirodela polyrrhiza</i> (L.) Schleid.	Araceae	Perennial	(S), M, (W)	Hydrophyte	Fl		
<i>Hydrocotyle petelotii</i> Tard.	Araliaceae	Annual	S, W	Mesophyte	Lv	Picked ^m	Phak Neek
<i>Hydrocotyle vulgaris</i> L.	Araliaceae	Perennial	S, M, W	Hygrophyte	Lv, Bk	Picked ^s	Phak Nook Vian
<i>Hydrocotyle</i> sp.	Araliaceae	Perennial	S, M, W	Mesophyte	Lv, Fl, Bk		
<i>Ageratina adenophora</i> (Spreng.) King & H. E. Robins	Asteraceae	Perennial	S, M, (W)	Mesophyte	Lv, Bk	Cut	
<i>Ageratum conyzoides</i> L.	Asteraceae	Annual	M	Mesophyte	Lv**, Fl, Bk	Cut	
<i>Artemisia</i> sp.	Asteraceae	Perennial	S, M, (W)	Mesophyte	Lv, Bk	Cut	
<i>Bidens pilosa</i> L.	Asteraceae	Annual	S, M	Mesophyte	Lv*, Fl, Bk**	Cut	
<i>Blumea</i> sp.	Asteraceae	Annual	S, W	Mesophyte	Lv, Bk	Cut	
<i>Chromolaena odorata</i> (L.) King & H. E. Robins	Asteraceae	Perennial	S, M, (W)	Mesophyte	Lv, Bk	Cut	
<i>Conyza sumatrensis</i> (Retz.) Walker	Asteraceae	Annual	M	Mesophyte	Lv, Bk	Cut	
<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Asteraceae	Annual	S, M	Mesophyte	Lv, Bk	Picked ^m	Phak Nya Mai Phak Aanamang Phak Hiang Nyon
<i>Eclipta prostrata</i> L.	Asteraceae	Annual	S, M	Mesophyte	Lv, Fl, Bk		

Table 1. Wild herbaceous species in paddy fields at Xamneua village and Nasakang village, Houaphan Province in the Lao PDR.

Scientific name	Family	Life-form	Season ^{a)}	Water ad. ^{b)}	Habitat ^{c)}	Management ^{d)}	Local name
<i>Emilia sonchifolia</i> (L.) DC.	Asteraceae	Annual	M	Mesophyte	Lv, Bk	Cut	
<i>Laphangium luteoalbum</i> (L.) Tzvelev	Asteraceae	Annual	S, W	Mesophyte	Lv, Fl	Picked ^m	Phak Keep
<i>Gnaphalium pensylvanicum</i> Willd.	Asteraceae	Annual	S, W	Mesophyte	Lv, Fl	Cut	
<i>Inula</i> sp.	Asteraceae	Annual	S, W	Mesophyte	Lv, Bk	Cut	
<i>Sonchus</i> sp.	Asteraceae	Perennial	S, M, (W)	Mesophyte	Lv, Bk	Cut	
<i>Spilanthes oleracea</i> L.	Asteraceae	Perennial	S, M, W	Mesophyte	Lv*, Bk	Picked ^m	Phak Salaat
<i>Hydrocera triflora</i> (L.) Wight & Arn.	Balsaminaceae	Perennial	S, M, (W)	Mesophyte	Bk	Cut	
<i>Impatiens chinensis</i> L.	Balsaminaceae	Perennial	S, M, (W)	Mesophyte	Lv, Bk	Cut	
<i>Bothriospermum tenellum</i> (Hornem.) Fisch. & C. A. Mey.	Boraginaceae	Annual	S, W	Mesophyte	Lv, Fl		
<i>Nasturtium officinale</i> R. Br.	Brassicaceae	Perennial	S, M, W	Hydrophyte	Dt	Picked ^m	Phak Khaat Nam
<i>Pratia nummularia</i> (Lam.) A. Br. & Aschers.	Campanulaceae	Annual	S, W	Mesophyte	Lv	Picked ^m	Phak Haak Khouay Phak Banbat
<i>Wahlenbergia marginata</i> (Thunb.) A. DC.	Campanulaceae	Perennial	S, (M), W	Mesophyte	Lv, Fl*		
<i>Polycarpon tetraphyllum</i> L.	Caryophyllaceae	Annual	S, W	Mesophyte	Lv, Fl		
<i>Myosoton aquaticum</i> (L.) Moench	Caryophyllaceae	Annual	S, W	Mesophyte	Lv	Picked ^m	Phak Soop Seep
<i>Commelina communis</i> L.	Commelinaceae	Perennial	S, M, W	Hygrophyte	Lv, Fl, Bk	Picked ^m	Phak Nyaa Kaap
<i>Cyanotis axillaris</i> (L.) D. Don ex Sweet	Commelinaceae	Perennial	S, M, W	Hygrophyte	Lv, Fl, Bk	Picked ^m	Phak Lap Thoot
<i>Ipomoea aquatica</i> Forssk.	Convolvulaceae	Perennial	S, M, W	Hygrophyte	Bk	Picked ^s	
<i>Cyperus difformis</i> L.	Cyperaceae	Annual	M	Hygrophyte	Lv, Fl, Bk	Cut, Uprooted	
<i>Cyperus haspan</i> L.	Cyperaceae	Annual	M	Hygrophyte	Fl	Uprooted	

Table 1. Wild herbaceous species in paddy fields at Xamneua village and Nasakang village, Houaphan Province in the Lao PDR.

Scientific name	Family	Life-form	Season ^{a)}	Water ad. ^{b)}	Habitat ^{c)}	Management ^{d)}	Local name
<i>Cyperus iria</i> L.	Cyperaceae	Annual	M	Mesophyte	Lv, Bk	Cut	
<i>Cyperus</i> sp. 1	Cyperaceae	Annual	M	Mesophyte	Lv, Fl, Bk	Cut, Uprooted	
<i>Cyperus</i> sp. 2	Cyperaceae	Perennial	S, M, (W)	Hygrophyte	Lv, Fl, Bk	Cut, Uprooted	
<i>Fimbristylis cymosa</i> R. Br.	Cyperaceae	Annual	M	Hygrophyte	Lv, Fl*	Uprooted	
<i>Fimbristylis miliacea</i> (L.) Vahl	Cyperaceae	Annual	M	Hygrophyte	Lv, Fl	Cut, Uprooted	
<i>Fimbristylis</i> sp. 1	Cyperaceae	Annual	M	Hygrophyte	Lv, Bk	Cut	
<i>Fimbristylis</i> sp. 2	Cyperaceae	Annual	M	Hygrophyte	Lv, Bk	Cut	
<i>Kyllingia brevifolia</i> Rottb.	Cyperaceae	Perennial	(S), M, (W)	Mesophyte	Lv**, Bk	Cut	
<i>Scirpus</i> sp.	Cyperaceae	Perennial	(S), M, (W)	Hygrophyte	Fl	Uprooted	
<i>Equisetum</i> sp.	Equisetaceae	Perennial	S, M, W	Mesophyte	Lv*, Bk	Cut	
<i>Aeschynomene indica</i> L.	Fabaceae	Annual	M	Mesophyte	Lv, Bk	Cut	
<i>Astragalus sinicus</i> L.	Fabaceae	Annual	S, W	Mesophyte	Lv, Fl	Picked ^m	Phak Seng
<i>Desmodium</i> sp. 1	Fabaceae	Perennial	S, M, (W)	Mesophyte	Lv		
<i>Desmodium</i> sp. 2	Fabaceae	Perennial	S, M, (W)	Mesophyte	Lv		
<i>Uraria</i> sp.	Fabaceae	Perennial	S, M, (W)	Mesophyte	Lv, Bk		
<i>Blyxa aubertii</i> Rich.	Hydrocharitaceae	Annual	M	Hydrophyte	Fl	Uprooted	
<i>Hypericum japonicum</i> Thunb.	Hypericaceae	Annual	S, M, (W)	Mesophyte	Lv, Fl, Bk		
<i>Hypericum</i> sp.	Hypericaceae	Annual	S, W	Mesophyte	Lv, Fl, Bk		
<i>Juncus effusus</i> L.	Juncaceae	Perennial	S, M, W	Hygrophyte	Lv	Cut	
<i>Juncus prismatocarpus</i> R. Br.	Juncaceae	Perennial	S, (M), W	Hygrophyte	Lv, Fl	Picked ^m , Uprooted ^m	Phak Phen Pheum
<i>Euthralis</i> sp.	Lamiaceae	Annual	M	Mesophyte	Lv, Bk	Cut	
<i>Leucas</i> sp.	Lamiaceae	Annual	M	Mesophyte	Lv, Bk	Cut	
<i>Utricularia aurea</i> Lour.	Lentibulariaceae	Annual	M	Hydrophyte	Fl*	Uprooted	
<i>Lindernia anagallis</i> (Burm.f.) Penn.	Linderniaceae	Annual	M	Mesophyte	Lv, Fl		

Table 1. Wild herbaceous species in paddy fields at Xamneua village and Nasakang village, Houaphan Province in the Lao PDR.

Scientific name	Family	Life-form	Season ^{a)}	Water ad. ^{b)}	Habitat ^{c)}	Management ^{d)}	Local name
<i>Lindernia</i> sp. 1	Linderniaceae	Annual	M	Mesophyte	Lv		
<i>Lindernia</i> sp. 2	Linderniaceae	Annual	M	Mesophyte	Lv	Picked ^m	Phak Kaan Pou
<i>Torenia</i> sp. 1	Linderniaceae	Annual	M	Mesophyte	Lv, Bk		
<i>Torenia</i> sp. 2	Linderniaceae	Annual	M	Mesophyte	Lv, Bk		
<i>Lygodium</i> sp.	Lygodiaceae	Perennial	S, M, W	Mesophyte	Lv, Bk	Cut	
<i>Rotala rotundifolia</i> (Buch.-Ham. ex Roxb.) Koehne	Lythraceae	Perennial	S, M, W	Hygrophyte	Lv, Fl**		
<i>Rotala</i> sp.	Lythraceae	Annual	M	Hygrophyte	Fl		
<i>Hibiscus</i> sp.	Malvaceae	Perennial	S, M, W	Mesophyte	Bk	Cut	
<i>Sida rhombifolia</i> L.	Malvaceae	Perennial	S, M, W	Mesophyte	Lv, Bk	Cut	
<i>Urena lobata</i> L.	Malvaceae	Perennial	S, M, (W)	Mesophyte	Lv, Bk	Cut	
<i>Marsilea quadrifolia</i> L.	Marsileaceae	Perennial	S, M, (W)	Hygrophyte	Lv, Dt, Fl**	Picked ^m , Uprooted ^m	Phak Ven
<i>Mazus pumilus</i> (Burm.f.) Steenis	Mazaceae	Annual	S, M	Mesophyte	Lv, Fl		
<i>Ludwigia adscendens</i> (L.) H. Hara	Onagraceae	Perennial	S, M, W	Hygrophyte	Lv, Fl*, Bk	Uprooted	Nya Poot
<i>Ludwigia hyssopifolia</i> (G. Don) Exell	Onagraceae	Annual	M	Hygrophyte	Lv, Fl	Uprooted	
<i>Ludwigia octovalvis</i> ssp. <i>octovalvis</i> (Jacq.) P. H. Raven	Onagraceae	Perennial	S, M, (W)	Mesophyte	Lv, Bk	Cut	
<i>Phyllanthus niruri</i> L.	Phyllanthaceae	Annual	M	Mesophyte	Lv	Cut	
<i>Dopatrium junceum</i> (Roxb.) Buch. - Ham. ex Benth.	Plantaginaceae	Annual	M	Hygrophyte	Fl		
<i>Limnophila</i> sp.	Plantaginaceae	Perennial	M	Hygrophyte	Lv, Fl		
<i>Plantago asiatica</i> L.	Plantaginaceae	Perennial	S, M, W	Mesophyte	Lv, Fl		
<i>Scoparia dulcis</i> L.	Plantaginaceae	Annual	M	Mesophyte	Lv, Bk	Cut	
<i>Alopecurus japonicus</i> Steud.	Poaceae	Annual	S, W	Mesophyte	Fl		

Table 1. Wild herbaceous species in paddy fields at Xamneua village and Nasakang village, Houaphan Province in the Lao PDR.

Scientific name	Family	Life-form	Season ^{a)}	Water ad. ^{b)}	Habitat ^{c)}	Management ^{d)}	Local name
<i>Brachiaria</i> sp.	Poaceae	Annual	M	Mesophyte	Lv	Cut	
<i>Chrysopogon aciculatus</i> (Retz.) Trin.	Poaceae	Perennial	M	Mesophyte	Lv*	Cut	
<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Perennial	S, M, W	Mesophyte	Lv*, Bk		
<i>Dichanthium annulatum</i> (Forssk.) Stapf	Poaceae	Perennial	S, M, W	Mesophyte	Lv		
<i>Digitaria</i> sp. 1	Poaceae	Perennial	S, M, W	Mesophyte	Lv, Fl**, Bk	Cut, Uprooted	Nya Waay
<i>Digitaria</i> sp. 2	Poaceae	Perennial	S, M, W	Mesophyte	Lv	Picked ^m	Phak Nya Khouay
<i>Echinochloa crus-galli</i> (L.) P.Beauv.	Poaceae	Annual	M	Mesophyte	Fl	Uprooted	Nya Wang
<i>Eleusine indica</i> (L.) Gaertn.	Poaceae	Annual	M	Mesophyte	Lv, Fl	Cut	
<i>Imperata cylindrica</i> (L.) P. Beauv.	Poaceae	Perennial	S, M, W	Mesophyte	Lv, Bk	Cut	
<i>Leersia hexandra</i> Sw.	Poaceae	Perennial	S, M, W	Hygrophyte	Lv, Bk**	Cut	
<i>Panicum repens</i> L.	Poaceae	Perennial	S, M, W	Mesophyte	Lv*, Fl, Bk	Cut, Uprooted	Nya Waay
<i>Paspalum conjugatum</i> P. J. Bergius	Poaceae	Perennial	S, M, W	Mesophyte	Lv**, Bk**	Cut	Nya Feet
<i>Paspalum urvillei</i> Steud.	Poaceae	Perennial	S, M, W	Mesophyte	Lv, Bk	Cut	
<i>Paspalum</i> sp.	Poaceae	Perennial	S, M, W	Mesophyte	Fl	Uprooted	
<i>Rottboellia cochinchinensis</i> (Lour.) W. D. Clayton	Poaceae	Annual	M	Mesophyte	Lv, Bk	Cut	
<i>Sacciolepis indica</i> (L.) Chase	Poaceae	Annual	M	Mesophyte	Lv, Fl, Bk	Cut	
<i>Setaria pallide-fusca</i> (Schum.) Stapf & Hubb.	Poaceae	Annual	M	Mesophyte	Lv, Fl*, Bk	Cut	
<i>Polygonum chinense</i> L.	Polygonaceae	Perennial	S, M, W	Mesophyte	Lv, Bk	Cut	
<i>Polygonum plebeium</i> R. Br.	Polygonaceae	Annual	S, W	Mesophyte	Lv, Fl, Bk		
<i>Polygonum</i> sp. 1	Polygonaceae	Annual	S, M	Hygrophyte	Lv, Fl, Bk	Cut	

Table 1. Wild herbaceous species in paddy fields at Xamneua village and Nasakang village, Houaphan Province in the Lao PDR.

Scientific name	Family	Life-form	Season ^{a)}	Water ad. ^{b)}	Habitat ^{c)}	Management ^{d)}	Local name
<i>Polygonum</i> sp. 2	Polygonaceae	Annual	S, W	Hygrophyte	Lv, Fl, Bk	Cut	
<i>Polygonum</i> sp. 3	Polygonaceae	Annual	S, W	Hygrophyte	Lv	Picked ^m	Phak Maimoo Maimian
<i>Rumex maritimus</i> L.	Polygonaceae	Perennial	S, M, (W)	Mesophyte	Lv, Bk	Cut	
<i>Monochoria hastata</i> (L.) Solms	Pontederiaceae	Perennial	S, M, W	Hydrophyte	Dt	Picked ^m	Phak Thop
<i>Monochoria vaginalis</i> (Brum.f.) Presl	Pontederiaceae	Annual	M	Hydrophyte	Fl*	Picked ^m , Uprooted ^m	Phak Li Hiin Phak Nang Hiin
<i>Hedyotis diffusa</i> Willd.	Rubiaceae	Annual	M	Mesophyte	Lv, Fl		
<i>Azolla pinnata</i> R. Br.	Salviniaceae	Perennial	(S), M, (W)	Hydrophyte	Fl*		
<i>Houttuynia cordata</i> Thunb.	Saururaceae	Perennial	S, M, (W)	Mesophyte	Lv	Picked ^m	Phak Khao Thong
<i>Pouzolzia hirta</i> (Blume) Blume ex Hassk.	Urticaceae	Perennial	S, M, W	Mesophyte	Lv, Bk	Cut	
<i>Viola</i> sp.	Violaceae	Annual	S	Mesophyte	Lv	Picked ^m	Phak Khon Houat
Unidentified (Pteridophyte)		Perennial	S, M, (W)	Mesophyte	Lv	Cut	
Unidentified (Pteridophyte)		Perennial	S, M, (W)	Mesophyte	Bk	Cut	

a) Season is indicated as: S, summer; M, monsoon season; W, winter.

b) Water ad. means water adaptability.

c) Habitat is indicated as: Bk, bank; Dt, ditch; Fl, field; Lv, levee. Species abundance is shown by asterisks: ** ISV > 0.2, * ISV > 0.1 in field; ** abundant in more than five plots, * abundant in more than one plot on levees and banks.

d) Use and management are indicated as: Cut, stems are cut with a long-handled sword on levees or banks; Picked, young leaves are picked as vegetables; Uprooted, plants are uprooted from the field. Superscript ^s indicates the ones picked or uprooted as vegetables for harvesters' consumption and superscript ^m indicates the ones for both harvesters' consumption and sale in the Xamneua market. Prostrating species on levees and banks escaped being cut and less abundant species in fields escaped being uprooted.

Table 2. Relative abundance of mixed wild edible herbs gathered in paddy fields sold at the Xamneua market in Houaphan Province, the Lao PDR.

Scientific name	Family	Mar 2-4	Mar 25-27	May 2-4	Jul 2-4	Jul 27-29	Nov 16-18
<i>Alternanthera sessilis</i> (L.) R.Br. ex DC.	Amaranthaceae		+				
<i>Centella asiatica</i> (L.) Urb.	Apiaceae	++	+	+		+	+++
<i>Eryngium foetidum</i> L.	Apiaceae	+	+	++	++	+	++
<i>Hydrocotyle petelotii</i> Tard.	Araliaceae	+	+				
<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Asteraceae		+	+			
<i>Laphangium luteoalbum</i> (L.) Tzvelev	Asteraceae	+					
<i>Spilanthes oleracea</i> L.	Asteraceae	+	++	++	+++	+++	+
<i>Nasturtium officinale</i> R. Br.	Brassicaceae		+				
<i>Pratia nummularia</i> (Lam.) A. Br. & Aschers.	Campanulaceae					+	++
<i>Myosoton aquaticum</i> (L.) Moench	Caryophyllaceae	+					
<i>Commelina communis</i> L.	Commelinaceae	+	+	+			
<i>Cyanotis axillaris</i> (L.) D.Don ex Sweet	Commelinaceae	+	++				
<i>Astragalus sinicus</i> L.	Fabaceae	+					
<i>Juncus prismatocarpus</i> R. Br.	Juncaceae	+++	++				
<i>Marsilea quadrifolia</i> L.	Marsileaceae	++	++	+++	+++	+++	++
<i>Digitaria</i> sp.	Poaceae			+++	+		
<i>Polygonum</i> sp.	Polygonaceae	+	+				
<i>Monochoria hastata</i> (L.) Solms	Pontederiaceae	+	++	++			+++
<i>Monochoria vaginalis</i> (Brum.f.) Presl	Pontederiaceae				+++	+++	
<i>Houttuynia cordata</i> Thunb.	Saururaceae		+				

Table 2. Relative abundance of mixed wild edible herbs gathered in paddy fields sold at the Xamneua market in Houaphan Province, the Lao PDR.

(continued)

Scientific name	Family	Mar	Mar	May	Jul	Jul	Nov
		2-4	25-27	2-4	2-4	27-29	16-18
<i>Lindernia</i> sp.	Scrophulariaceae		+				
<i>Viola</i> sp.	Violaceae		+				
Number of species		13	16	8	5	6	6

+++, large portion (> 0.2 of relative abundance); ++, moderate portion (> 0.1); +, small portion (< 0.1).