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Gathering of Wild Food Plants in Anthropogenic Environments across the Seasons: Implications for Poor and Vulnerable Farm Households

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Gathering of Wild Food Plants in Anthropogenic Environments across the Seasons: Implications for Poor and Vulnerable Farm Households

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This article presents the results of a study conducted in Northeast Thailand on wild food plant gathering in anthropogenic areas and the implications for vulnerable households. A sub-sample of 40 farming households was visited every month to conduct seven–day recalls over a 12-month period on wild food plant acquisition events. Results show that these plants are an essential part of the diet, constituting a "rural safety net" particularly for vulnerable households. Findings reveal that anthropogenic environments have seasonal complementarity throughout the year with respect to wild food gathering and farmer's gathering of wild food plants from anthropogenic environments complements seasonal crop availability. This study contributes to a deeper understanding of these plants as a household asset and their potential contribution to household well-being. The results of this study furthers our understanding of dietary traditions and the scientific challenge of the partitions that have for decades divided agriculturalists and gatherers.

KEYWORDS agricultural biodiversity, coping strategies, food security, gathering, poverty, rice farmers, seasonality, Southeast Asia, Thailand, wild food plants

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The "Cross-cutting Initiative on Biodiversity for Food and Nutrition" led by FAO and Bioversity International, under the umbrella of the Convention of Biological Diversity, recognizes the essential role of agricultural biodiversity for improving the nutritional and health situation of the poor (Heywood 2011). In this regard, wild food plants, which exist on a continuum of human management from "truly" wild to semi-domesticated and cultivated species (Harris 1989; Wiersum 1997), are crucial for most vulnerable families such as those with chronically ill members (Barany et al. 2001; Johns and Eyzaguirre 2006) and for people who have few assets in terms of land, livestock, or cash (Daniggelis 2003). Moreover, diversification in agricultural systems, including those promoting wild food plant availability, is particularly important for most vulnerable social groups: the higher the diversity, the greater their self-reliance (Heywood 2011). Nevertheless, studies on the seasonal implications of wild food plant gathering from diversified agricultural systems for vulnerable families are extremely rare. Likewise, little importance has been given to the contribution of this resource in the food security debate (Price and Ogle 2008).

Gathering and consumption of wild food plants from anthropogenic areas, defined as environments disturbed by human activity, particularly agricultural fields and home gardens, have been documented in multiple cultural contexts with millions of people in rural areas dependent upon the role they play in food security and dietary diversity (Bharucha and Pretty 2010; Cotton 1996; Etkin 1994; Eyssartier et al. 2011; Heywood 1999; Scoones, Melnyk, and Pretty 1992; Pieroni 2003). For example, it has been documented that farming families in Vietnam gather wild food plants from various agricultural environments (Ogle and Grivetti 1985) and these species constitute essential sources of macro and micro nutrients (Ogle et al. 2001). The nutritional importance of these foods has also been recognized in Thailand (Ngarmsak 1987). For instance, not only in Northern Thailand do *Sígaw Karen* people collect wild food plants from rice fields, fallow agricultural areas and forests (Johnson and Grivetti 2002), but also in the Northeast of the country we find that *Isaan* farmers gather these foods from home gardens and different habitats such as water ponds and shelters in diversified rice systems (Cruz-Garcia and Price 2011).

Gathering of wild resources constitutes a crucial household coping strategy in times of famine or scarcity for farming societies from around the world. These plants have a major importance during lean seasons complementing seasonal crop availability when farming households do not have enough staple foods because the stored harvest is finished (Adaya et al. 1997; Heywood 1999; Scoones et al. 1992; Grivetti and Ogle 2000). Wild food plants constitute an essential buffer against hunger for those rice farming communities attaining low yields in Southeast Asia (Bharucha and Pretty 2010), especially during lean months preceding harvesting, which is certainly the case in Northeast Thailand (Prapertchob 2001).

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Huss-Ashmore (1988), in her introduction to the book *Coping with Seasonal Constraints*, emphasised that the study of seasonality, specifically intra-annual fluctuations, and their impact on rural societies has largely been neglected. She also remarked that a clear understanding of the relationships between environmental seasonality and the seasonality of human response is needed. Although it is widely recognized that wild food plants are important for the food security and dietary diversity of vulnerable families, their seasonal consumption has only been documented by very few authors. For example, in Côte d'Ivoire, Herzog and colleagues (1996) conducted monthly 24-hour recalls on food intake, including uncultivated plants, over a one year period. Nordeide and colleagues (1996) conducted interviews on food consumption frequency of green leaves and other wild foods in the rainy season and post-harvest season in a number of villages in Southern Mali. Mertz and colleagues (2001) kept food diaries of wild and cultivated vegetables with 14 households in south-eastern Burkina Faso. Nevertheless, none of these studies analyzed the seasonal contributions of different anthropogenic environments in providing these plants and such studies have never been conducted among rice farming communities in Northeast Thailand. This is certainly necessary for achieving a thorough understanding of the actual implications of this resource during the course of the year especially for the poor and more vulnerable households in this region.

This study provides the results of a detailed investigation on wild food plant gathering in a farming village in Northeast Thailand. The objective of this study was to investigate the seasonal complementarity of different anthropogenic environments for wild food plant collection throughout the year, analyzing gathering events for household food consumption. The gathering data is interfaced with a selection of household economic and demographic variables of the same families. Finally, wild food plant gathering in relation to vulnerable households is analyzed and discussed.

This study uses Niehof's definition (2004, 323) of household as a "family-based co-residential unit" that shares most household resources, daily activities and takes care of the primary needs of its members. Vulnerable households are those that are unable to create, maintain or possess sufficient assets for addressing their basic needs, which makes them unable to cope with stress, change and risks without being harmed (Niehof and Price 2001). Although migrants do not participate in daily household activities, they are considered household members in this study because they may contribute through remittances.

The research was conducted in Kalasin Province, Northeast Thailand. This region is also locally referred to as *Isaan*. Kalasin is located at 152 m above sea level on the Korat Plateau, which geographically defines this region. Soils are highly saline, poorly drained and with low fertility (Parnwell 1988). The region is characterized by a Tropical Savannah climate (Köppen "Aw") (Wijnhoud 2007) with an annual monsoon defining a rainy season that

provides 90% of the annual rainfall. This season has a monthly average rainfall of 214 mm, maximum temperature of 32 °C and minimum temperature of 24 °C. The dry season, which is divided into a hot and a cool period, has a monthly average rainfall of 23 mm, maximum temperature of 32 °C and minimum temperature of 19 °C (Hijmans et al. 2005).

The Northeast is the poorest region in Thailand, where 20% of households have an annual income at or below that listed as average household monthly income (National Statistical Office of Thailand 2001). The staple in Northeast Thailand is glutinous rice consumed with a diversity of wild foods gathered largely from rice fields, home gardens, roadsides and woods (Cruz-Garcia and Price 2011). Wild food plants are integrated into numerous local recipes as well as eaten raw as a snack or side dish. Women are the main wild food plant gatherers and the main custodians of the knowledge on species specific management, use and preparation, guarding the food security and nutritional diversity of their families (Price and Ogle 2008; Moreno-Black, Somnasang, and Thamthawan 1994).

The production of transplanted glutinous rice, which has low yields in comparison to the rest of the country (Prapertchob 2001), occurs in the rainy season. Some farmers have upland fields where they produce cash crops such as sugar cane or cassava. Paddy rice fields present a diversity of habitats such as shelters, water ponds and hillocks, where wild food plants grow. In the dry season farmers with access to irrigation will produce direct seeded rice, vegetables, and mushrooms. The presence of apple snails (locally called "cherry snails" due to the pink colour of their eggs) is a serious problem for rice production. Farmers apply molluscicides after rice transplanting and some poisonings have been reported among rice farmers using molluscicides or herbicides. Another important concern of the farmers is Leptospirosis, which is a bacterial infection mainly transmitted by field rats. People can be infected through Leptospirosis urine contaminated soil, water and food.

Households in the rural areas of Kalasin have on average four family members (National Statistical Office of Thailand 2001). Customary inheritance of land is through women and residence is matrilocal, facilitating women's detailed knowledge of their physical and social environment (Price and Ogle 2008). Traditionally a stem family cycle starts when daughters once married bring their spouses to live within the parental home. When the first child is born, they build a separate house within the parental household compound. During this period, called multi-household compound, daughter's and parents' households share land, labour and rice. The youngest daughter and her husband will never move out of her parents' house, which she will inherit. Inheritance of land mainly occurs when the parents are old and land is distributed among daughters (Foster 1978; Mizuno 1978; Price 2003). The stem family cycle, however, is being affected by out-migration.

Rural Thai households depending on small scale and subsistence production, especially from the Northeast, are characterized by the presence of seasonal or permanent out-migration for labour in the urban industrial

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economy. Economic returns, however, may not be frequent or adequate enough and vary among households (Mills 1997). Remittances are economically important because they diversify income, but the loss of farm labour due to migration constitutes a problem for the local agricultural economy. Remittances are mainly utilized for meeting basic needs and occasionally conspicuous consumption (Jones and Kittisuksathit 2003).

METHODS

Field work was conducted from March 2008 to February 2009 in two adjacent villages with a total of 136 households, where the authors identified a total of 87 wild food plants growing in anthropogenic environments including plants consumed as fruits and vegetables (Cruz-Garcia and Price 2011). The botanical identification of plant species was conducted by local taxonomists of Walai Rukhavej Botanical Research Institute of Mahasarakham University and the Department of Biology of Chang Mai University. Data collection was carried out with the authorization of the National Research Council of Thailand (NRCT). NRCT approved the study protocol and all informants who participated in the study did it so freely and with consent.

Firstly, the village cropping calendar was verified with key informants, who were identified by the villagers themselves as the more knowledgeable about the local resources and farming related activities. Secondly, a 100% sample of the village was selected for an in-depth demographic and socioeconomic household census ($n = 136$ households). Thirdly, a total of 40 households were selected from the census (equivalent to almost 30%), for conducting the seven-day recalls over a 12-month period on wild food plant acquisition events. Twenty of these households were randomly selected, whereas the other half was purposely selected as vulnerable in terms of having any chronically ill family member, having many children or elderly, or being landless.

For the household census, demographic and socioeconomic data was provided by the family heads (either the father or the mother). The list of variables, which was defined with local specialists that had ample research experience on the socioeconomic situation of Northeast Thailand (Chamruspanth 2001; Chamruspanth and Kunurat 2000), included household composition, presence of chronically ill household members, household assets and household economics (Appendix 1A). Furthermore, household vulnerability, migration and material style of life (MSL) were calculated per household (Appendix 1B, 1C, and 1D). Household vulnerability was analyzed in relation to presence of chronic illness, total dependency ratio, ownership of rice fields and household economics.

The independent one-sample *t*-test was conducted in order to analyze the representativeness of the sample with respect to the village population.

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Results showed that only two out of 15 analyzed variables were not representative of the population, namely presence of adult migrants and number of adult migrants in the household (at .05 and .10 level, respectively). Households were not purposely selected with respect to migration, but migrants happened to be over-represented in the household sample. These differences, however, did not have a major influence on the results of this study, because, as will be explained later, migration showed to have no influence on wild food plant gathering. In contrast, despite that 20 households were purposely selected for the presence of any chronically ill member, the sample was representative of the population regarding this variable (Appendix 2).

The 40 sampled households were visited every month to conduct seven-day recalls over a 12-month period on wild food plant acquisition events. Seven-day recalls were chosen because the reference period of one week was recommended over one-day or two-week recalls, given the impossibility of doing personal consumption diaries (Beegle et al. 2010). Semi-structured interviews were conducted with female heads of households given that it has been reported by previous research that women in Northeast Thailand are the main knowledge holders and gatherers of wild food plants as they procure for their household's daily food consumption (Moreno-Black, Somnasang, and Thamthawan 1994; Price 2003; Price and Ogle 2008). Women were asked about wild food plants acquired, mode of acquisition, purpose of acquisition and place where the plant was obtained.

Data was entered in a relational data base (Microsoft Access ©) in terms of acquisition events with one event being one household's acquisition in an explicit acquisition mode (gathering, purchase, received as a gift) with in particular purpose (to eat, to offer to the temple, to give as present, for exchange) of one specific species, in a specific place and in a given month. Given that the focus of this article is on gathering of wild food plants for family consumption, only gathering events for the purpose *to eat* were further analyzed. In this way, one gathering event refers to one household's gathering of one specific species in a specific environment and in a given month, with the purpose of consumption. Using these data the following variables were calculated for analysing the seasonality of wild food gathering across anthropogenic environments:

- Number of gathering events per month in each environment.
- Number of species gathered per month in each environment.
- Number of households gathering wild food plants per month in each environment.

Non-parametric statistical analysis was applied to explore the effect of household profiles on wild food plant gathering and the relation between

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household vulnerability and gathering using the PASW Statistics 18 software (formerly SPSS Statistics). Data on household number of gathering events and amount of species gathered per month in each environment were compared to household demographic and socioeconomic variables. Wilcoxon-Mann-Whitney tests were conducted in the analysis of household nominal binary variables, namely presence of chronic illness and migration. Spearman rank-order correlation coefficients were obtained in order to assess the possible association between gathering variables and ordinal or interval household variables, i.e. total dependency ratio, income, expenditures, gross income, remittances, debts and material style of life (Siegel 1988). Only probability values below or equal to .05 are considered statistically significant. Results that reach the .10 level of probability are reported as approaching statistical significance in order to indicate a trend.

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RESULTS

Acquisition of Wild Food Plants

A total of 2,460 wild food plant acquisition events were reported from the monthly seven-day recalls with the 40 households sampled throughout the year. From this total, 89% of the events corresponded to gathering, 10% to market purchase and 1% of plants were obtained as a present. Most gathering events were done with the purpose to eat (2196 events). Of gathering events, 46 were meant for preparing food and giving it as an offering to feed the Buddhist monks; three events were meant to give the food item as a present; and two for exchange. A few gathering events had a double purpose (2%), for example to eat and also to give as a food offering to the monks. The focus of this article is only on wild food plants gathered for the purpose of eating, so the results of this article are based on these 2,196 gathering events.

Overall households gathered a total of 50 different wild food plant species to eat corresponding to 32 botanical families (table 1). About 16% of the plants were from the Leguminosae family and 11 botanical families presented two species, namely Annonaceae, Bignonaceae, Clusiacea, Cucurbiataceae, Lecythidaceae, Meliaceae, Menispermacea, Myrtaceae, Pontederiaceae, Sapindaceae, and Zingiberaceae. The rest of the families presented only one species. From the botanical description of wild food plants published by the same authors (2011), 46% of the species are trees, 18% terrestrial herbs, 14% aquatic herbs, 12% climbers, 8% shrubs and one species is a rattan. It is important to emphasize that in the rainy season the monthly average number of gathered wild food plant species was 32, almost 50% higher than in the dry season (22 species). All sampled households gathered wild food plants throughout most of the year: 80% of households gathering every single month and 13% gathering 11 months out of the year. Only two families gathered 10 months and one gathered 7 months out of the year.

TABLE 1 List of wild food plant species gathered to eat indicating botanical family, scientific name, local name in Thai script and English transliteration of local name[1, 2]

Scientific name	English transliteration of local (*Isaan*) name	Local (*Isaan*) name
Aizoaceae		
Glinus oppositifolius (L.) Aug.DC.	Phak kaen khom	ผักแก่นขม
Amaranthaceae		
Amaranthus viridis L.	Phak hom	ผักหม
Anacardiacea		
Spondias pinnata Kurz	Bak kawek	บักกอก
Annonaceae		
Polyalthia debilis Finet & Gagnep.	Bak lok kok	บักลกคก
Polyalthia evecta Finet & Gagnep.	Bak tong leeng	บักต้องแล่ง
Arecaceae		
Calamus sp.	Bak waai	บักหวาย
	Waai	หวาย
Asclepiadaceae		
Telosma minor Craib	Phak kik	ผักขิก
	Dok kik	ดอกขิก
	Bak kik	บักขิก
Basellaceae		
Basella rubra L.	Phak pang	ผักปัง
Bignonaceae		
Dolichandrone serrulata Seem.	Kee paa	แคป่า
Oroxylum indicum Vent.	Phak lin faa	ผักลิ้นฟ้า
	Bak lin faa	บักลิ้นฟ้า
	Yod lin faa	ยอดลิ้นฟ้า
	Bai lin faa	ใบลิ้นฟ้า
Campanulaceae		
Lobelia begonifolia Wall.	Phak luem phua	ผักลืมผัว
Clusiacea		
Cratoxylum formosum (Jack) Benth. & Hook.f. ex Dyer	Phak tew	ผักติ้ว
Garcinia cowa Roxb.	Phak moong	ผักโมง
	Bak moong	บักโมง
Compositae		
Emilia sonchifolia (L.) DC.	Phak lin pii	ผักลิ้นปี่
Convolvulaceae		
Ipomoea aquatica Forssk.	Phak bung	ผักบุ้ง
Cucurbiataceae		
Coccinia grandis (L.) Voigt	Phak tam nin	ผักตำนิน
	Bak tam nin	บักตำนิน

(*Continued*)

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TABLE 1 (Continued)

Scientific name	English transliteration of local (*Isaan*) name	Local (*Isaan*) name
	Tam nin	ตำนิน
Momordica charantia L.	Phak sai	ผักไส่
	Bak phak sai	บักผักไส่
Euphorbiaceae		
Phyllanthus acidus (L.) Skeels	Bak yom	บักยม
	Yod bak yom	ยอดบักยม
Hydrocharitaceae		
Ottelia alismoides (L.) Pers.	Phak hob hep	ผักโหบเหบ
Lecythidaceae		
Barringtonia acutangula (L.) Gaertn.	Phak kadon naam	ผักกะโดนน้ำ
	Kadon naam	กะโดนน้ำ
Careya arborea Roxb.	Phak kadon kok	ผักกะโดนโคก
	Kadon kok	กะโดนโคก
Leguminosae		
Adenanthera pavonina L.	Phak lam	ผักล่ำ
Leucaena leucocephala (Lam.) de Wit	Phak kased	ผักกะเสด
	Bak kased	บักกะเสด
	Yod phak kased	ยอดผักกะเสด
	Kased	กะเสด
Neptunia oleracea Lour.	Phak kased naam	ผักกะเสดน้ำ
Pithecellobium dulce (Roxb.) Benth.	Bak kaam lian	บักขามเลียน
	Kaam lian	ขามเลียน
Cajanus cajan (L.) Millsp.	Bak tua heea	บักถั่วแฮ
	Tua heea	ถั่วแฮ
Cassia siamea Lam.	Phak khee lek	ผักขี้เหล็ก
	Khee lek	ขี้เหล็ก
Senna sophera (L.) Roxb.	Phak let ket	ผักเล็ดเด็ด
Tamarindus indica L.	Bak kaam	บักขาม
	Bak kaam som	บักขามส้ม
	Maak kaam	หมากขาม
	Yod kaam	ยอดขาม
Limnocharitaceae		
Limnocharis flava Buchenau	Phak kanjong	ผักคันจอง
	Bak kanjong	บักคันจอง
	Phak pai	ผักพาย
Marsileaceae		
Marsilea crenata C.Presl	Phak waen	ผักแว่น
Meliaceae		
Azadirachta indica A.Juss. var. *indica*	Phak ki nin	ผักคินิน
Azadirachta indica A.Juss. var. *siamensis* Valeton	Phak kadaw	ผักกะเดา
	Yod kadaw	ยอดกะเดา
	Yod phak kadaw	ยอดผักกะเดา
Menispermacea		
Cissampelos pareira L.	Bai maa noi	ใบหมาน้อย

(*Continued*)

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TABLE 1 (Continued)

Scientific name	English transliteration of local (*Isaan*) name	Local (*Isaan*) name
	Maa noi	หมาน้อย
Tiliacora triandra Diels	Yaa nang	ย่านาง
	Bai yaa nang	ใบย่านาง
Myrtaceae		
Psidium guajava L.	Bak sidaa noi	บักสีดาน้อย
Syzygium gratum (Wight) S.N.Mitra	Phak mek	ผักเม็ก
	Maak mek	หมากเม็ก
Nymphaeaceae		
Nymphaea pubescens Willd.	Phak sai bua	ผักสายบัว
	Sai bua	สายบัว
Opiliaceae		
Melientha suavis Pierre	Phak waan paa	ผักหวานป่า
Pontederiaceae		
Monochoria hastata (L.) Solms	Phak top	ผักตบ
	Phak top thai	ผักตบไทย
Monochoria vaginalis C.Presl	Phak e-hin	ผักอีฮิน
Rhamnaceae		
Ziziphus mauritiana Lam.	Bak tan noi	บักทันน้อย
Rubiaceae		
Oxyceros horridus Lour.	Bai kat kaaw	ใบคัดเค้า
Rutaceae		
Aegle marmelos Corrêa	Bak tuum	บักตูม
	Maak tuum	หมากตูม
	Yod maak tuum	ยอดหมากตูม
Sapindaceae		
Lepisanthes rubiginosa (Roxb.) Leenh.	Bak huat kaa	บักหวดข่า
Schleichera oleosa (Lour.) Oken	Bak kawe	บักค้อ
	Luk kawe	ลูกค้อ
	Maak kawe	หมากค้อ
Scrophulariaceae		
Limnophila aromatica Merr.	Phak kayang	ผักกะแยง
Umbelliferae		
Centella asiatica (L.) Urb.	Phak nok	ผักหนอก
Zingiberaceae		
Alpinia malaccensis C.Presl	Kaa paa	คาป่า
Curcuma singularis Gagnep.	Dok ka-jeeuw	ดอกกะเจียว

[1] A more extensive list is published in Cruz-Garcia and Price (2011).

[2] North-easterners speak a dialect of the Lao language called Isaan that is written using the Thai script. Prefixes are important for plant naming mainly referring to the edible part of the plant. For instance, *bak* and *maak* mean fruit (**บัก**, **หมาก**), *yod* means shoots (**ยอด**), *bai* refers to leaf (**ใบ**), and *dok* means flower (**ดอก**). Another frequent prefix is *phak* that means vegetable (**ผัก**) (Price 1997), including shoots, leaves, stems and even whole aerial parts consumed as vegetable.

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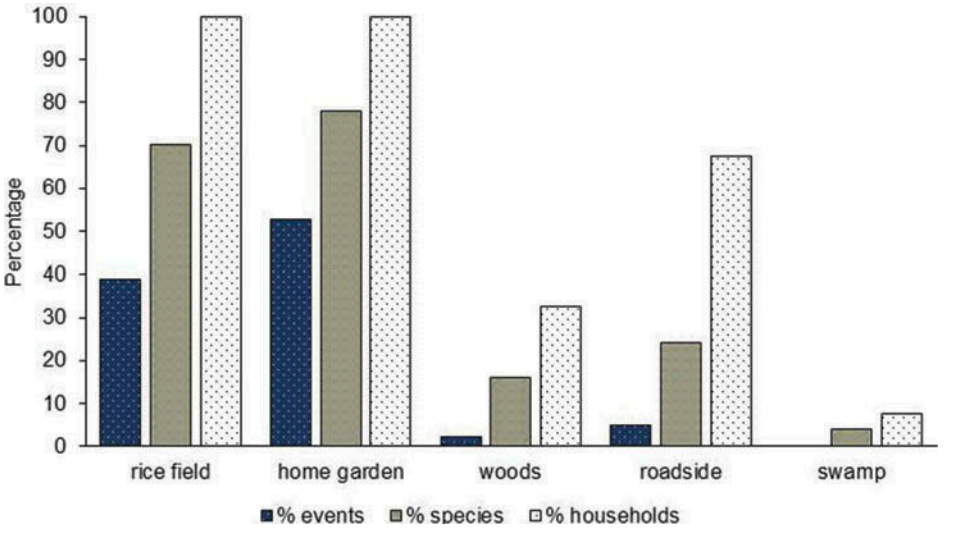

FIGURE 1 Percentage of gathering events for eating in one year (n = 2,196 events), percentage of species gathered (n = 50 species), and households gathering in each environment (n = 40 households).

All households gathered wild food plants from paddy fields and home gardens, and most of them (68%) also from roadsides (figure 1). The highest percentages of species gathered and gathering events corresponded to home gardens (78% of species, 53% of events), followed by paddy fields (70% of species, 39% of events). Five percent of all gathering events occurred in roadsides, corresponding to 24% of species. One third of households gathered from secondary woody areas (33%) and only few households from swamps (8%), corresponding to 16% and 4% of the species, respectively.

Seasonal Complementarity of Different Anthropogenic Environments

More than half of the gathering events occurred in the six months that make up the rainy season (62%). The rainy season starts in May and afterwards rice transplanting occurs in June and July. The percentage of households gathering wild food plants in home gardens and rice fields was very constant and complementary during this season (figure 2). The number of gathering events in these areas also remained almost constant during the rainy season, reaching its maximum in September, which coincides with the maximum rainfall reported in this year and maximum plant height before grain development of transplanted rice. This is also the pre-harvest period when grain stocks and earnings from the previous harvest are lowest in farming communities.

With regard to the specific environments during certain periods of the rainy season, the number of species gathered in rice fields decreased by almost 50% in July when farmers applied pesticides. In August this

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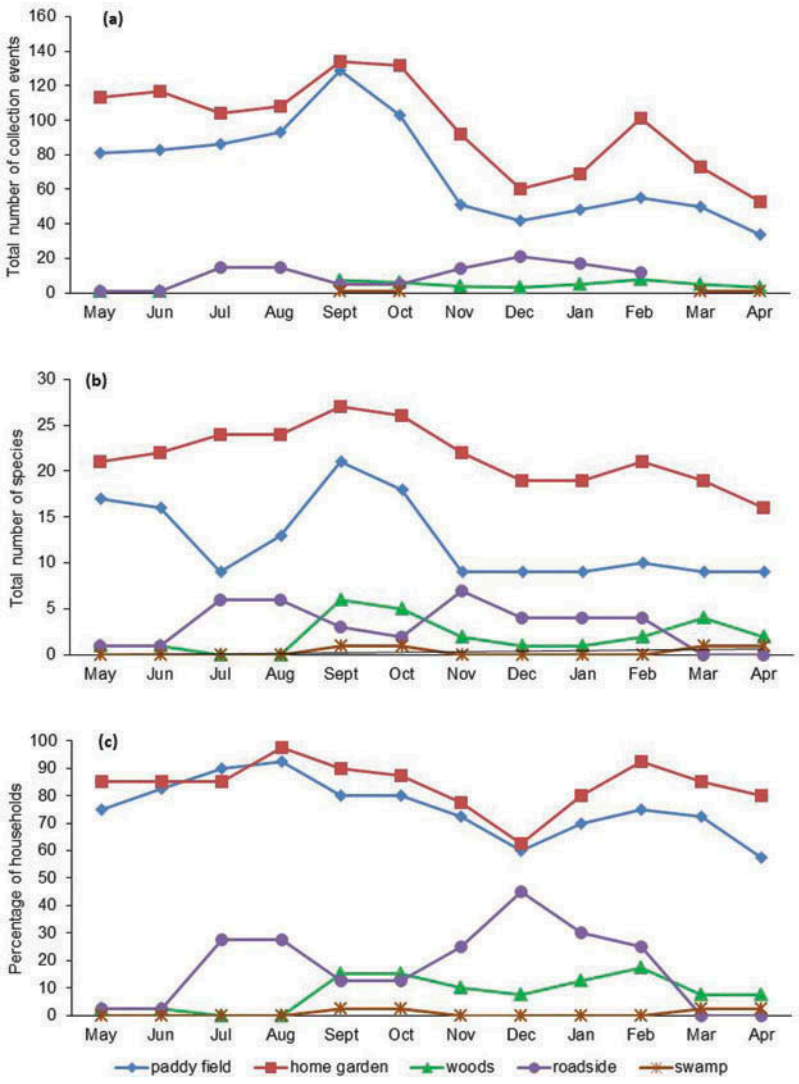

FIGURE 2 Wild food plant gathering throughout the year per environment, presenting results of seven-day recalls conducted monthly ($n = 40$ households): (a) Number of collection events ($n = 2{,}196$); (b) Number of species gathered ($n = 50$); (c) Percentage of households gathering wild food plants ($n = 40$). Rainy season occurs from May to October; dry season includes a cool period from November to February and a hot period from March to April.

percentage increased only slightly (figure 2). This phenomenon was not reflected in the observed number of gathering events or in the percentage of households gathering. This is because farmers stopped gathering wild food plant species that grew in the aquatic and semi-aquatic habitats of paddy fields, but they continued collecting from terrestrial subsystems in the rice fields, such as shelters and hillocks, and increased their gathering

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from roadsides. During these two months, the number of collection events, species gathered and percentage of households gathering wild food plants from roadsides reached its highest point in the season.

People generally wait three weeks after pesticide applications before they start gathering again from the field areas they think are impacted. Most farmers (76%) remarked that they are afraid of getting ill due to pesticide poisoning or Leptospirosis, both of which have already been reported as occurring in the village.

The rainy season ends in the month of October when usually both the rice stocks in the household granary and the money obtained from the prior harvest are finished. Although there was a great decrease in rainfall, the number of collection events, species gathered and percentage of households gathering wild food plants remained very high this month.

Gathering of wild food plants decreased with the beginning of the dry season (cool period) and harvesting of transplanted rice in November. After harvesting most farmers burn the straw that is left in their fields, usually in November and December. This was clearly reflected in the remarkable decrease in the number of gathering events, species gathered and households gathering in the paddies, which reached their lowest values in these months. November and December were also characterized by a substantial increase in wild food plant gathering at roadsides, most noteworthy in the fact that the percentage of households gathering in this area reached its yearly maximum of 45%. Wild food plant gathering in home gardens also decreased after rice harvesting.

After rice harvesting and straw burning, those farmers with access to irrigation water will cultivate direct-seeded rice, mushrooms, or vegetables. Pesticide application, which takes place in January, has no impact on wild food gathering in paddies because usually no edible weeds grow at the field borders of direct-seeded rice. During the dry season, gathering in paddies, which only occurs in shelters, hillocks and (half-) dried ponds, was considerably less than in the rainy season because only a few edible weed species grow and few trees provide fruit under the dry conditions of this season. Surprisingly, the percentage of households that kept on gathering wild plants was very high despite the low number of food species available in the paddies. Gathering of these few species, more importantly the herbs *Ipomoea aquatica, Centella asiatica*, and *Glinus oppositifolius*, remained constant throughout these months given that they play an important role in the dry season's local diet. Regarding home gardens, the number of gathering events also decreased in the dry season, but there was no notable decrease on the diversity of species gathered nor on the percentage of households that gather these species.

A second food shortage occurred during the lean months of March and April before direct seeded rice harvesting, corresponding to the hot period of the dry season. In this period, the availability of wild food plants

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across all environments dramatically decreased due to high temperatures and extremely dry conditions, which was clearly reflected in the decline of gathering events. The percentage of households gathering plants, however, remained high because these families depended on these few key species available.

Finally, the number of gathering events and species gathered in woods and swamps was very low throughout the year. Gathering from these areas was mainly related to the environmental availability of specific wild food plant species. Woods mainly provide seasonal gourmet or delicacy fruits, as well as edible flowers.

Vulnerability, Migration, and Wild Food Plant Gathering

Household vulnerability was assessed by the presence of chronic illness, total dependency ratio, ownership of rice field and household economics. In addition, the influence of migration and material style of life (MSL) on gathering was controlled in the data analysis. Households with a chronically ill family member reported gathering fewer species from rice fields (Wilcoxon-Mann-Whitney test at the 0.10 level) but reported more gathering events from roadsides (Wilcoxon-Mann-Whitney test at the 0.10 level). Landless households reported on average 3.7 times more gathering events from roadsides and gathered 1.4 more species from roadsides than those households owning a paddy field. Otherwise, there was no significant difference in gathering with respect to area of land owned. Although MSL was not initially considered a variable related to vulnerability, households with a lower MSL also reported more gathering events (Spearman's ρ at 0.05) and species gathered (Spearman's ρ at 0.10) at roadsides.

No relations were found between wild food plant gathering with income and expenditures separately, but the influence of gross income, which is equivalent to income minus expenditures, on gathering was significant. Households with lower gross income reported more gathering events across all environments (Spearman's ρ at 0.10), gathered more species in total (Spearman's ρ at 0.05), and gathered more species in rice fields and home gardens (Spearman's ρ at 0.10). Households with higher debts reported fewer gathering events (Spearman's ρ at 0.10). Households with lower remittances reported more gathering events and species gathered at roadsides (Spearman's ρ at 0.10).

No relationship between migration, number of gathering events and number of wild food plant species gathered in any of the agricultural environments appeared in the results. In the same way, there were no differences observed between total dependency ratio including and excluding migrants with respect to gathering. In both cases households with a higher dependency ratio gathered a greater number of wild food plant species across

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all environments (Spearman's ρ at 0.05). No significant differences were observed with respect to specific areas.

DISCUSSION AND CONCLUSION

The results of this study revealed some important aspects for understanding the seasonal complementarity of the various anthropogenic environments' contribution to wild food plants gathered by villagers and the tremendous implications for the household diet in Northeast Thailand, particularly for vulnerable households. These environments encompass the entire range of activity locations in the daily life of the farmers, including home gardens, paddy fields, roadsides, secondary woods and swamps. Likewise each environment provides aquatic, semi-aquatic and/or terrestrial habitats fulfilling niche requirements of different species.

Implications for Nutritional Diversity and Food Security in Northeast Thailand

The research findings show that wild food plant gathering from anthropogenic environments was done mainly for the purpose of domestic consumption. The great diversity of wild food plants gathered in this area reaffirmed for Northeast Thailand the general statement that wild foods play an important role diversifying the local diet, as concluded in a published comparative analysis of wild food gathering in agricultural areas around the world (Bharucha and Pretty 2010). This article establishes that wild food plants are an important component of local food security based on the high monthly percentages of households gathering them for domestic consumption, the high monthly number of gathered species and the high number of wild food plant collection events recorded using seven-day recalls over a 12-month period. Despite the seasonal variations in the number of gathering events and number of species gathered, the percentage of households gathering plants was almost constant throughout the year, which implies that this resource is in general essential for local families regardless of seasonality.

This is comparable to the findings of Shackleton and colleagues (1998), who reported that all of the surveyed households in the central Lowveld savannah region in South Africa consumed wild vegetables. Similarly, Pérez-Negrón and Casas (2007) reported that 96% of surveyed households in Santiago Quiotepec, Mexico, gathered cultivated and wild edible plants, and nearly 88% of households gathered wild fruit. This was, however, not the case among Chepang people of Nepal, where only 58% of households consumed uncultivated foods for more than 3.5 months a year (Prasad Aryal, Berg, and Ogle 2009).

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Importance of Anthropogenic Environments

It has been asserted that dietary diversity is founded on farming systems diversity (Frison, Cherfas, and Hodgkin 2011). This study provides evidence to assure that this is also the case for Northeast Thailand, where people gather numerous wild food plant species from a wide array of anthropogenic farming systems including home gardens, paddy fields, roadsides, secondary woods and swamps. Likewise each environment provides aquatic, semi-aquatic and/or terrestrial habitats fulfilling niche requirements of different species of edible trees, shrubs, herbs, vines, and rattans.

Farmers gather wild food plants across farming environments depending on their access possibilities as well as species availability. In addition, when gathering occurs on the private property of a neighbour, gathering depends on species specific gathering rights that may vary per location (Price 1997). In this way, the landless may be able to collect only limited amounts of wild food plants from other's rice fields subject to the species in question.

The results of this study illustrate that home gardens and rice fields constitute the most important sources of wild food plants, reflected in the high number of species gathered (ranging from 16 to 27 per month for home gardens and from 9 to 21 for rice fields) and the high percentage of households gathering wild food plants in these environments (ranging from 63% to 98% per month for home gardens and from 58% to 93% for rice fields). Home gardens constitute an integral component of the farming system (Kumar and Nair 2004) and play an essential role in counteracting malnutrition and food insecurity (Kehlenbeck, Susilo Arifin, and Maass 2007). Similarly, it has been documented that agricultural fields are essential for providing not only staple crops but also wild food plants crucial for the food security of farming communities (Scoones et al. 1992; Price and Ogle 2008).

The maintenance of almost a constant number of species gathered in home gardens all year round, even surprisingly keeping high values during the dry season, implies the presence of human management. Indeed, it has been reported that farmers cultivate and manage wild food plants in Northeast Thai home gardens (Moreno-Black et al. 1996; Price 2005; Wester and Yongvanit 1995). However, wild food plant gathering in paddies presented much higher monthly variations, due primarily to species environmental availability and cultivation practices in transplanted rice.

Seasonal Implications of Wild Food Plant Gathering

Results show that wild food plant gathering is important throughout the year, even after rice harvesting when families have increased their resources. This is reflected in the high number of gathering events reported with the seven-day monthly recalls (ranging from 279 to 93 per month), the fact that most households (80%) gathered wild food plants every single month of the year, and the high percentages of household gathering these plants every month.

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The year-round consumption of wild food plants has also been reported across the world, for example in Arribes del Duero, Spain (González, García-Barriuso, and Amich 2011), the Tehuacán-Cuicatlán valley in Mexico (Pérez-Negrón and Casas 2007) and in Southern Zambia (Mnzava 1997).

It is possible to conclude from the results of this study that wild food plants constitute a "rural safety net" acting as a buffer against food shortage during the following lean months:

- October, when 100% of households depended on 32 wild food plant species before harvesting of transplanted rice.
- March and April, corresponding to the hot season when, despite the dramatic decrease on the environmental availability of several species, from 98% to 100% of households relied on the remaining 18 to 23 species.

Likewise, the important role of wild food plants for household food security during food shortages has also been reported for other rice farming communities and agricultural societies in the world. For instance, during the *monga* season in Bangladesh, when stored food is finished before rice harvesting (Mendoza and Johnson 2008), households depend on non-conventional food plants with a high content of amino acids, minerals, and essential fatty acids for meeting their basic nutritional needs (Kumar Paul et al. 2011). During periods of seasonal stress corresponding to the end of the rainy season, the diet of *Tuareg* pastoralists depends on nutritious wild grasses, among other resources (Smith 1992). Wild food plants provide farmers in West Africa with essential nutrients and additional calories during periods of famine (Lockett, Calvert, and Grivetti 2000) and have been important for survival during times of food shortages in different Mediterranean countries (González et al. 2011).

The Influence of Pesticide Application and Wild Food Plant Gathering in Paddies

This case study provides evidence that most farmers are afraid to get sick when collecting or consuming wild food plants from rice fields because of pesticide intoxication or Leptospirosis. These farmers wait three weeks after pesticide application for re-starting their gathering activities in aquatic and semi-aquatic habitats of rice fields. This was reflected in a dramatic decrease of almost 50% less species gathered from rice fields in the month of July.

The negative effects of pesticide application on wild food plant gathering has also been documented in Northern Thailand, where some respondents asserted that pesticide use, which caused illness among families and livestock in the area, was the major threat to the availability of wild edible plants growing along paddy waterways (Johnson and Grivetti 2002). In a study conducted in Central Thailand, which is characterized by

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high input rice production, it was documented that pesticide application and land use changes contributed to the decrease of wild food plant gathering in the paddies (Price 2000). To the contrary, in a study conducted in Laguna and Nueva Ecija, the Philippines, where farmers were not aware of the potential negative effects that the excessive use of pesticides would have for human health, it was documented that the amount of wild food gathered from their paddy fields was not affected by the level of pesticide application (Warburton, Palis, and Pingali 1995).

Implications for Vulnerable Households

The fact that vulnerable households in terms of lower gross income and higher dependency ratio gather a significantly higher number of wild food plant species across anthropogenic environments shows that they rely significantly more on biodiversity. From these findings it is possible to assert that wild food plant gathering constitutes an important household coping strategy especially for the most vulnerable families who are those less able to deal with situations of stress.

These findings are consistent with the results of a comparative analysis of wild food gathering across continents concluding that this resource is important to the poorest households worldwide (Bharucha and Pretty 2010). For example, the poorest families in Kurigram District, Bangladesh, depend heavily on nonconventional plants during the famine periods (Islam et al. 2011), in South Africa poor families without a constant income depend more on wild and cultivated local vegetables (Hart 2011) and wild food plants are critical to the survival of the most vulnerable people in West Africa (Lockett et al. 2000).

The importance of wild food plants for families with a high dependency ratio has also been reported in other regions such as Limpopo Province, South Africa, where indigenous vegetables, including wild plants, are essential for children and the elderly (Hart 2011). In another district of the same country, it was found that households with an increased dependency ratio due to adult mortality rely more on wild vegetables (Twine and Hunter 2010).

Households with any chronically ill family member or elderly have labor constraints. This was observed in the lower number of species gathered from rice fields in comparison to the other households. These families prefer to gather closer to their house, either in home gardens or roadsides. The proximity of home gardens to the house is convenient for assuring food security especially for these families whose members cannot usually manage to gather wild food plants in agricultural areas. This was also observed in a study conducted in rural Ghana, where Akrofi and colleagues (2010) found that households with an HIV chronically ill family member had a more diverse diet, specially due to the consumption of more food plant species gathered from gardens that are closer to home.

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Public roadsides are important areas in terms of wild food plant gathering not only for families with a chronically ill member, but also for vulnerable households in general and during those months when it is not possible to gather from the paddies. This was reflected in the following three findings:

- Families with a chronically ill member, the landless, households with lower remittances, and those with a lower material style of life (MSL) reported considerably more gathering events from roadsides.
- Landless households, households with lower remittances, and those with a lower material style of life (MSL) gathered a higher number of species from roadsides.
- The number of gathering events and percentage of households gathering from roadsides were higher during the months of pesticide application and straw burning in the paddies.

Roadsides can be regarded either as a secondary option when families cannot gather in paddies or as an important buffer complementing rice fields.

Migration and Gathering

Remittances, as additional cash income, had a negative relationship with wild food gathering, whereas migration per se was not a variable influencing gathering. Not all migrants send remittances to their families in the village and the amount of money they send is variable. The presence of migrants in a family did not show any statistical relation with the number of wild food plant gathering events and species gathered and, moreover, there were no differences observed between both dependency ratios, including and excluding migrants, with respect to gathering.

To the contrary, Wester and Yongvanit (1995) suggest that out-migration in Northeast Thailand may contribute to the decrease in wild food plant knowledge and use. This assertion, however, could be more relevant for the younger generations, when migration would affect wild food plant gathering due to the current absence of knowledge transmission from parents to their children. Migration was not an issue when current gatherers learned about wild food plants from their parents. Nowadays, however, almost a whole adult/parental generation is missing in the village due to migration, thus traditional patterns of knowledge transfer are certainly being affected. Setalaphruk and Price (2007), who recently conducted research in the same village, stated that although children are able to identify wild food plants by their names, they lack specific tactic knowledge with respect to gathering practices. In this way, there is an ongoing process of knowledge erosion that certainly will have consequences on wild food plant gathering in the future.

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The findings of the research presented in this article have a number of important implications. The significance of this study crosses the boundary between basic science and strategic science. Scientifically, the results of this study further our understanding of dietary traditions and their potential evolution through our empirically grounded challenge of the partitions that have for decades divided agriculturalists and gatherers. The sharp distinction between growing plants and gathering plants as two very separate livelihood strategies along a continuum of social and livelihood evolution will be further questioned. We also believe this study contributes to a deeper understanding of these plants as a household asset and their potential contribution to household well-being. While there is significant interest in wild food plants among nutritionists, botanists and anthropologists, voices speaking out from the applied strategic research world for understanding, protecting and improving this component of the farming food system for the dietary welfare of farmers are still inaudible. Strategic agricultural research continues to focus generally on wild relatives of crops or those that are termed "traditional vegetables" in a manner that excludes most wild food plants, overlooking their actual place and importance in the farming system and the households that rely on them for sustenance throughout the year.

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APPENDIX 1 Information Recorded in the Household Census and Calculation of Household Variables

A. Demographic and socio-economic data recorded for each household during the census:
– Household composition, specifying number of children, elderly and adults. Individuals who were 14 years old or younger were classified as children, whereas elderly were 65 years or older. Working age adults were older than 14 and younger than 65 years (United Nations 2001).
–Presence of chronically ill household members.
–Household assets in terms of ownership of rice field, area of field and possession of goods (TV, fan, radio, refrigerator, rice cooker, stove, car, motorcycle, bicycle, plough, mobile phone, home phone, computer and stereo).
–Household economics, in terms of total income, remittances, expenditures and debts in the year. Income was quantified including the sale of rice, cows, buffalos, ducks, chicken, vegetables, fish, pigs, as well as wage labour. Expenditures included the costs of rice production (ploughing, sowing, transplanting, harvesting, milling, seeds and agro-chemicals), petrol, food, clothes, medicines, electricity, irrigation water, telephone, donations to the Buddhist temple and children's education. Debts include money borrowed from the village fund, the Agricultural Cooperative Bank, Government Savings Bank, relatives, private money lenders and other sources.

B. Calculation of household vulnerability:
Household vulnerability was analysed in relation to presence of chronic illness, total dependency ratio, ownership of rice field and economics. These variables were calculated as follows:
–Presence of chronic illness was recorded as either present or absent in any household member.
–Total dependency ratio was calculated as the number of children and elderly in relation to the number of working age adults including and excluding migrants, according to these formulas adjusted from the 'World Population Ageing 1950-2050' report of the United Nations (2001):

$$\text{Total dependency ratio including migrants} = \frac{(\text{number of children + elderly}) \times 100}{\text{number of adults including migrants}}$$

$$\text{Total dependency ratio excluding migrants} = \frac{(\text{number of children + elderly}) \times 100}{\text{number of adults excluding migrants}}$$

The higher the ratio, the higher the burden on the working age adults to maintain the children and elderly, who are assumed to be economically dependent on them. It is important to remark that chronically ill working age adults were not subtracted to calculate dependency ratios (presence of chronic illness was analysed separately).
–A household was classified as either a landowner or landless. Households were recorded as landowning when: (a) they work in their own field, (b) they work in a field of their parents, which could also be the case depending on the stage of family phase, (c) they work in a field given by relatives with use rights, so the household does not have to give anything in exchange to their relatives.
–The following economic variables were obtained: total income (including remittances), total expenditures, total gross income (income minus expenditures) and total debts per year. In some analysis total remittances was also used as a variable, especially when examining migration. Remittances were included in the final calculation of total income after analysing and observing that both migration and remittances did not have any significant effect on wild food plant gathering (discussed later in this article).

C. Calculation of migration:
–Migration (permanent or seasonal) was calculated as presence or absence of any adult migrant in the household, as well as number of migrants per household.

(*Continued*)

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APPENDIX 1
(Continued)

D. Calculation of material style of life (MSL):
−Material style of life, which is an indicator of relative wealth in a community, summarizes the data on household material goods assets in one single index. Goods were ordered in a Guttman scale from most to least common among households that were assigned scale types according to their possession of goods (Van Willigen and De Walt 1985; De Walt 1979). The higher the scale the more goods the household possesses, including least common goods, which are usually the most expensive such as a car or computer.

APPENDIX 2 Demographic and Socioeconomic Profile of the Households Comparing Means (or Percentages if Explicitly Indicated) of Village Population and Sample, Indicating the Significance of the Independent One-Sample *t*-test

	Population[1] (n = 136)	Sample[2] (n = 40)	*t*-test significance[3]
Demographic information			
Household size (nr)	4.7	5.2	
Children (nr)	0.9	1.1	
Elderly (nr)	0.3	0.3	
Adult migrants (nr)	1.1	1.5	0.084
Total dependency ratio including migrants[4]	48.9	41.1	
Total dependency ratio excluding migrants	91.6	84.8	
Households with adult migrants[5] (%)	58.2	72.5	0.036
Households with chronically ill members (%)	25	35	
Socioeconomic information: household assets			
Ownership of rice field[6] (%)	96.9	90	
Rice field area (ha)	1.5	1.4	
Material style of life[7]	11	11.4	
Socioeconomic information: annual household economics[8]			
Income (US$)	3055	3096	
Expenditures (US$)	2390	2499	
Gross income (US$)	665	598	
Debts (US$)	1431	1536	
Remittances (US$)	879	793	

[1]Missing values ranging from 0 to 2 for demographic variables and from 0 to 19 for socioeconomic variables.
[2]No missing values for demographic variables and missing values ranging from 0 to 7 for socioeconomic variables.
[3]Only significant values below or equal to 0.05 and trends at 0.10 are presented.
[4]Total dependency ratio is the relation of number of children (younger or equal to 14 years) and elderly (older or equal to 65 years) to the number of working age adults (older than 14 and younger than 65 years).
[5]Working age adults that migrated permanently or seasonally.
[6]Statistical analysis not conducted given the low number of landless households (n = 4).
[7]Material style of life is as an indicator of relative wealth that summarizes information on household goods assets; mean of total income, expenditures, gross income, debts and remittances for the year.
[8]One US$ = 29.925 Thai Bahts; exchange rate July 20, 2011.

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