

Production of non-timber forest products (NTFPs) and diversity of harvesters' practices and decision-making processes in northern Thailand community forests

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Photos 1.
Community forests (CF) at Lainan Sub-district, Nan Province,
northern Thailand: (a) lower CF, (b) middle CF, and (c) upper CF.
Photo W. Wimolsakcharoen.

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RÉSUMÉ

Production de produits forestiers non ligneux et diversité des pratiques de récolte et des processus décisionnels des exploitants dans les forêts communautaires du nord de la Thaïlande

Les recherches antérieures sur la foresterie communautaire en Thaïlande se sont principalement concentrées sur les dimensions institutionnelles. Par conséquent, les connaissances intégrées sur la production de produits forestiers non ligneux, les pratiques des exploitants et les processus de prise de décision sont encore limitées, particulièrement en ce qui concerne la foresterie communautaire. Une enquête a été réalisée pour estimer la production de produits forestiers non ligneux et pour caractériser la diversité des pratiques des exploitants et des processus de prise de décision dans les forêts communautaires du nord de la Thaïlande. Des enquêtes sur le terrain ont été menées une fois par mois pendant 12 mois dans sept forêts communautaires du sous-district de Lainan, dans la province de Nan, en utilisant une technique d'échantillonnage basée sur une grille. La production et la productivité des principaux produits forestiers non ligneux ont été calculées en fonction du poids frais total. Des entrevues individuelles approfondies ont été menées auprès de 231 cueilleurs locaux afin de comprendre les pratiques de récolte des produits forestiers non ligneux et les processus décisionnels. Les jeunes pousses de *Melientha suavis*, les couvées royales d'*Oecophylla smaragdina* et les champignons comestibles se sont avérés être les trois principaux produits forestiers non ligneux collectés, avec une productivité respectivement de 2, 12 et 2 kg/ha/an. Les pratiques de récolte des exploitants ont été caractérisées comme étant appliquées par (A) les villageois sans terre, (B) les petits et moyens propriétaires terriens, (C) les grands propriétaires terriens, et (D) les étrangers. Les pêcheurs locaux ont présenté différents processus de prise de décision en matière d'exploitation des ressources, selon la période d'occurrence des ressources, la durée de l'exploitation et la quantité récoltée. Les données quantitatives sur la productivité des ressources et la connaissance des pratiques de récolte et des processus décisionnels des exploitants alimenteront un processus participatif de gestion des ressources pour appuyer les échanges de connaissances entre les intervenants locaux et pour explorer des scénarios de règles d'accès appropriées, afin d'améliorer la durabilité de la récolte des produits forestiers non ligneux.

Mots-clés : *Melientha suavis*, *Oecophylla smaragdina*, champignons comestibles, cueillette, produits forestiers non ligneux, fourmi tisserande, cueilleur de champignons sauvages, Thaïlande.

ABSTRACT

Production of non-timber forest products (NTFPs) and diversity of harvesters' practices and decision-making processes in northern Thailand community forests

Previous research on community forestry in Thailand has mainly focused on its institutional dimensions. Comprehensive knowledge on the production of non-timber forest products and on harvesting practices and decision-making processes is therefore still limited, particularly in relation to community-based forestry. A survey was performed to estimate the production of non-timber forest products and to characterize the diversity of harvesting practices and decision-making processes in northern Thailand's community forests. Field investigations were conducted once a month for 12 months in seven community forests in the Lainan sub-district in Nan Province, using a grid-based sampling technique. Production and productivity of the main non-timber forest products were calculated by total fresh weight. In-depth interviews were conducted individually with 231 local harvesters to understand their non-timber forest product harvesting practices and decision-making processes. Young shoots of *Melientha suavis*, queen broods of *Oecophylla smaragdina* and edible mushrooms were found to be the three main non-timber forest products collected, with productivity of 2, 12, and 2 kg/ha/year, respectively. Harvesting practices were characterized as applied by (A) landless villagers, (B) small- and medium-sized landholders, (C) larger landholders, and (D) outsiders. Local harvesters displayed different decision-making processes in resource harvesting depending on periods of resource availability, the duration of harvests and the quantities harvested. These quantitative data on resource productivity together with knowledge of harvesting practices and decision-making processes among harvesters will provide input to a participatory resource management process to support exchanges of knowledge among local stakeholders and explore scenarios for appropriate rules of access so as to improve the sustainability of non-timber forest product harvesting.

Keywords: *Melientha suavis*, *Oecophylla smaragdina*, edible mushrooms, gathering practices, non-timber forest product, weaver ants, wild mushroom picker, Thailand.

RESUMEN

Producción de productos forestales no leñosos y diversidad de las prácticas de recolección y de los procesos decisivos de los explotadores forestales en los bosques comunales del norte de Tailandia

Las investigaciones anteriores sobre la dasonomía comunal en Tailandia se habían concentrado principalmente en los aspectos institucionales. Por tanto, los conocimientos integrados sobre la producción de productos forestales no leñosos, las prácticas de los explotadores forestales y los procesos de toma de decisión todavía son limitados, especialmente en cuanto a la dasonomía comunal. Se realizó un estudio para estimar la producción de productos forestales no leñosos y para caracterizar la diversidad de las prácticas de los explotadores forestales y de los procesos de toma de decisión en los bosques comunales del norte de Tailandia. Se llevaron a cabo estudios de campo una vez al mes durante doce meses en siete bosques comunales del subdistrito de Lainan, en la provincia de Nan, utilizando una técnica de muestreo basada en una cuadrícula. La producción y la productividad de los principales productos forestales no leñosos se calcularon en función del peso fresco total. Se realizaron entrevistas individuales en profundidad a 231 recolectores locales para comprender las prácticas de recolección de los productos forestales no leñosos y los procesos de toma de decisiones. Los brotes jóvenes de *Melientha suavis*, las crías reales de *Oecophylla smaragdina* y las setas comestibles resultaron ser los tres principales productos no leñosos recolectados, con una productividad respectivamente de 2, 12 y 2 kg/ha/año. Las prácticas de recolección de los explotadores forestales se caracterizaron como aplicadas por (A) los lugareños sin tierra, (B) los pequeños y medianos propietarios de tierras, (C) los grandes propietarios de tierras y (D) los extranjeros. Los recolectores locales presentaron diferentes procesos de toma de decisiones en materia de explotación de recursos según el período de incidencia de los recursos, la duración de la explotación y la cantidad recogida. Los datos cuantitativos sobre la productividad de los recursos y el conocimiento de las prácticas de recolección y de los procesos decisivos de los explotadores forestales alimentarán un proceso participativo de gestión de recursos para apoyar los intercambios de conocimientos entre los participantes locales y para explorar escenarios de normas de acceso apropiados para mejorar la durabilidad de la recolección de los productos forestales no leñosos.

Palabras clave: *Melientha suavis*, *Oecophylla smaragdina*, setas comestibles, cosecha, productos forestales no leñosos, hormiga tejedora, recolector de setas silvestres, Tailandia

Introduction

Non-timber forest products (NTFPs) encompass all biological materials except for timber that are found in a forest (Delang, 2006). They play an important role in local livelihoods as food, raw materials, traditional medicines, and ornaments for over two billion people all over the world (Sellato, 2002; Boissière *et al.*, 2013; Mukul *et al.*, 2016). South East Asia is one region of the world displaying a large number of producers and consumers of NTFPs (Mukul *et al.*, 2016).

Recently, natural populations of worldwide NTFPs, especially in tropical forests, have been made more vulnerable due to deforestation and overexploitation leading to decreased NTFP populations (Tewari, 2014; Lohbeck *et al.*, 2016). Some authors consider that better co-management of renewable resources with local stakeholders is needed to achieve a more sustainable production of NTFPs (Sikor *et al.*, 2017). Community forest management (CFM) has been promoted over the last few decades as a new paradigm shift linking ecological sustainability and the community in forest management (Pokharel *et al.*, 2015). Overall, CFM plays important roles in maintaining wildlife populations, producing NTFPs and supporting the lives of local communities, particularly resource-poor landholders (Mortimer *et al.*, 2012) who are often highly dependent on NTFPs for their economic survival (Barnaud *et al.*, 2008). Because small-scale family farms have low levels of financial and physical capital, they supplement their income through off-farm activities, including harvesting NTFPs (Robinson and Lokina, 2011).

In Thailand, CFM is a forest conservation approach integrating the dependency of local people on forest resources and involves not only the active protection of forest areas, but also regulations on logging prohibition and utilization of NTFPs (Salam *et al.*, 2006). In total, there are more than the 10,000 officially registered community forests in Thailand where NTFP harvesting is an integral part of local daily life (Gomontean *et al.*, 2008). Thailand's community forests provide at least 150 different kinds of NTFPs that consist of herbs, vegetables, edible fungi, insects, and other wild animals (Kabir and Webb, 2006). Among these diverse NTFPs, several can fetch high market prices (Sanoamuang, 2010).

Understanding the features of both NTFPs production, and the practices and decision-making processes of harvesters, is necessary to move towards a more sustainable collective management of such resources (Berg *et al.*, 2007). A search of the literature in the Thai Library Integrated System (ThaiLIS) database showed that previous research on community forestry in Thailand mainly focused on the institutional dimensions of collective management practices, rules and regulations, policy, law, and local indigenous knowledge. As a consequence, in-depth and integrated knowledge on NTFPs production, productivity, and harvesters' decision-making processes and practices in relation to CFM is still very limited. To fill this

gap, a survey was implemented to estimate the production and productivity of the major types of NTFPs and their variability in community forests at the sub-district and village levels. The study also aimed at characterizing the diversity of harvesters among different villages, based on their decision-making processes and practices related to NTFPs gathering.

Following characterization of the study site, the survey results on NTFPs production, productivity, and harvesters' decision-making processes and practices are presented. The following discussion covers the analysis of differences in NTFPs productivity among villages and compared with the literature, the support provided by NTFPs to the livelihoods of resource-poor households, and the access to NTFPs. Finally, based on the results from this survey, perspectives for improving the local rules of access to NTFPs are proposed.

Methods

Study site

Lainan Sub-district, located in Wiang Sa District of Nan Province, covers 125 km² and with an average current population density of lowland Thai people of 28 inhabitants/km² (Department of Provincial Administration, 2017) (figure 1). The majority of the working population farm their own land, with farm sizes ranging from 1.6-11.2 ha. A few villagers are landless, and several settlers are government officers. The field work was conducted at all seven community forests of this sub-district, where the forest areas are vulnerable due to deforestation. Several villages in the neighboring sub-districts have lost their own community forests during recent decades. Lainan's community forests have been operating officially for more than 40 years (photo 1) and the evolution of community forestry in this area can be interpreted based on a sequence of three main periods as follows (Nantasen *et al.*, 2005):

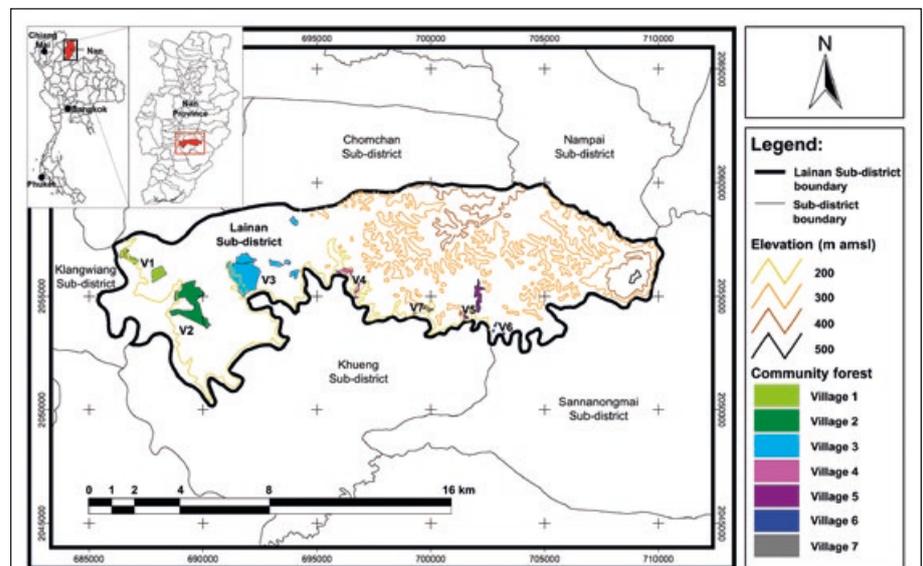


Figure 1. Location of the study site at Lainan Sub-district, Wiang Sa District, Nan Province, northern Thailand.

Table I.
Profile of the study site at Lainan Sub-district, Nan Province, northern Thailand.

Characteristic	Village number						
	1	2	3	4	5	6	7
Community forest attribute							
Geographical location (UTM zone 47Q, unit metre)	688,010 E 2,056,010 N	689,740 E 2,054,170 N	691,830 E 2,055,850 N	696,210 E 2,056,120 N	701,530 E 2,054,100 N	702,840 E 2,053,750 N	699,860 E 2,054,460 N
Topographical situation	Lower	Lower	Middle	Upper	Upper	Upper	Upper
Maximum elevation (m amsl)	280	265	300	330	305	310	320
Total area (1976-1995) (ha)	800	1,040	640	160	560	400	480
Total area (2009) (ha)	45	134	192	19	31	3	7
Decline in total area (%)	94	87	70	88	94	99	99
Grid-based sampling							
Number of grids (100 x 100 m ²)	27	125	139	12	3	2	6
Harvesting pressure							
Total number of households (HH)	273	254	149	238	145	47	48
Number of harvesting HHs	184	175	149	25	25	30	48
Estimated number of harvesters	234	225	249	25	25	35	53
Community forest rules and regulations							
Fine for logging (€/tree)	125	125	250	25	250	25	38
Fine for wildlife hunting (€/animal)	125	n/a	125	n/a	n/a	n/a	n/a
Fine for dumping waste in the forest (€)	250	250	63	13	n/a	n/a	n/a
Fine for burning (€)	n/a	250	125	n/a	n/a	13	n/a
Buddhist religious protection ritual	Yes	No	Yes	No	No	No	No

Source: Authors' own survey and adapted from Nantasen *et al.* (2005). amsl: above mean sea level. UTM: Universal Transverse Mercator.

▪ **1968-1975: Forest conservation activities.** Forests were conserved for the main purposes of (i) protecting the remaining forest areas from deforestation due to the government policy on logging concessions issued in 1963 and (ii) cattle grazing.

▪ **1976-1995: Official establishment of community forests.** Community forests in all villages of this sub-district were officially established and their boundaries delineated. Commanding rules and regulations for logging prohibition were introduced, and local management committees were set up.

▪ **Since 1996: Forest rehabilitation.** Because deforestation still occurred during the previous two periods, logging in community forests is strictly prohibited in every village. However, the close collaboration of local villagers in CFM and conservation is still limited as most of the villagers consider that CFM is mainly a duty of the village headmen and local CFM committees.

The characteristics of each selected community forest are presented in table I. Some villages, particularly lower ones, prohibit wildlife hunting, waste dumping, and forest burning. Lower villages also have Buddhist protection rituals as a part of their conservation culture combining religious and spiritual beliefs. The Sub-district Administrative Organization (SAO) plays a role to support CFM by providing

information and promoting collaboration in CFM among village headmen, CFM committees, and villagers. The SAO also allocates budgets for CFM activities, especially for the establishment of firebreaks and reforestation.

Data collection on NTFPs production

Preliminary surveys were conducted through interviews using a semi-structured guideline. The organization of the guideline (appendix 1) was as follows: list of NTFPs found in the community forests and their farm gate price, history and evolution of the community forestry, CFM rules and regulations, and current CFM problems. In each village, at least 15% of the households were randomly selected using a random numbers table based on the population database from SAO. They were stratified into three age classes; young (less than 18 years old), middle-aged (from 18 to 60 years old), and old (more than 60 years old) people. A total of 231 potential informants belonging to the 2nd and 3rd age classes were interviewed as very few young people come to harvest NTFPs in the community forests.

Field investigations were conducted in the NTFP harvesting areas of the seven community forests once a month for 12 months (from June 2015 to May 2016) using the

grid-based sampling technique (Stevens, 1997). The NTFP harvesting areas in all community forests were divided into grids of 100 x 100 m². The number of grids in each village depended on the size of the NTFP harvesting areas (table I). The number of grids of community forests belonging to villages 2 and 3 was far higher than the others because of the larger size of these two community forests. In village 5, the harvesting area was only 3 out of 31 ha because most of the community forest was steep cliffs.

Samples of the major NTFPs found at this site were collected and the scientific names of edible mushrooms were identified by using pictorial keys (Royal Society, 2007; Chandrasrikul *et al.*, 2008; Sanoamuang, 2010) before being checked by specialists from the Department of Botany at the Faculty of Science, Chulalongkorn University (Bangkok, Thailand).

The physical productivity and annual production of each kind of major NTFP were calculated according to their total fresh weight in all harvesting locations.

Data collection on the NTFP harvesters' decision-making processes and practices

To understand the NTFP harvesters' decision-making processes and related practices, in-depth individual interviews were conducted with 95 respondents covering the diversity of harvesters. Topics discussed in the interview were the main purpose of harvesting, the scheduling and daily duration of harvesting, the daily amounts of harvested products, their decision-making rules regarding harvesting (when and where to visit, use of seasonal harvesting patterns, etc.), and the practical harvesting techniques used for the main kinds of NTFPs recorded at the site.

Results

Major NTFPs found at the site

Melientha suavis Pierre, *Oecophylla smaragdina* Fabricius, and edible mushrooms were the three major NTFPs gathered by Lainan people and their characteristics are as follows:

- *M. suavis* is a deciduous tree belonging to the Opiliaceae family and is commonly found in the mixed deciduous and dry dipterocarp forests of Thailand (Prathepha, 2000; Julapak *et al.*, 2016). Its leaf is simple, alternate and shiny with an oval to round shape. The flowers are dioecious and assembled in panicles (Charoenchai *et al.*, 2013). During the dry season, from February to May, edible young shoots and young and/or blooming flowers are gathered by local people (Prathepha, 2000) (photo 2).
- *O. smaragdina* (weaver ant) is one of the most favored edible insects in many countries of South East Asia. It is an arboreal ant which builds nests by binding living leaves together and fixing them with silk produced from its larvae. Its colonies are polydomous and consist of multiple nests (Sribandit *et al.*, 2008; Van Itterbeeck *et al.*, 2014). Queen broods of *O. smaragdina*, which refer to larva and pupa destined to become new queens as well as their last stage as imago virgin queens, have been gathered as a source of food for centuries (Offenberg and Wiwatwitaya, 2010) (photo 3).

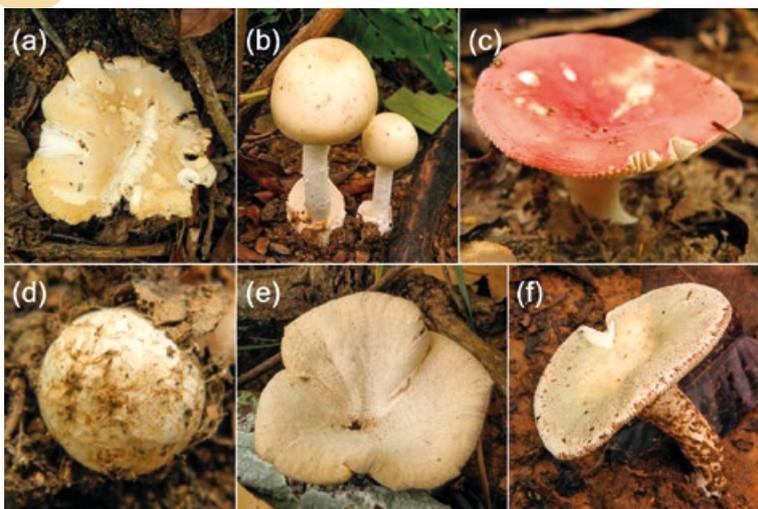


Photos 2.
 Individual tree of *Melientha suavis* in a community forest; small photo: harvested young shoots.
 Photo W. Wimolsakcharoen.



Photos 3.
 Traditional harvesting practice for *Oecophylla smaragdina*; small photo: queen broods. A long (around 7 m) bamboo stick with a net (usually a maize bag) mounted close to the pointed tip is used to pierce the *Oecophylla smaragdina* nests. When the bamboo stick is shaken, the queen brood and mature ants (mostly worker ants) are dropped into the net. Fine starch powder is used to prevent the worker ants from taking the brood out of the net. Only the broods are then collected in a container (usually a homemade basket used for sticky rice) (adapted from Sribandit *et al.*, 2008).
 Photo W. Wimolsakcharoen.

- Wild edible mushrooms have long been traditionally harvested from forests worldwide because they are difficult to domesticate and cultivate (Zhang *et al.*, 2014). In Thailand, several edible mushroom species, such as *Astraeus hygrometricus* (Pers.) Morgan, *Morchella conica* Dill. ex Pers., *Phlebopus portentosus* (Berk. & Broome) Boedijn, and *Pleurotus giganteus* (Berk.) Karunarathna & K.D. Hyde, are gathered by



Photos 4.

Some edible mushroom species found in the community forests at Lainan Sub-district, Nan Province, northern Thailand: (a) *Macrocybe crassa*, (b) *Amanita princeps*, (c) *Russula emetica*, (d) *Astraeus nan1*, (e) *Lentinus polychrous*, and (f) *Russula virescens*.

Photo W. Wimolsakcharoen.



Photos 5.

Edible mushrooms at a local market: (a) After completing harvest of edible mushrooms in the community forests, local harvesters sorted these mushrooms according to their farm gate price. High priced mushrooms (higher than 3 €/kg), such as *Astraeus nan1*, *Lentinus polychrous*, and *Russula virescens*, were sold separately, while low priced mushrooms were sold in mixtures. (b) Mixture of low priced edible mushrooms.

Photo W. Wimolsakcharoen.

rural people for household consumption (photo 4). Because of the high market price of some species, they also provide a complementary income for resource-poor households (photo 5) (Mortimer *et al.*, 2012).

These three categories of NTFPs are commonly found in the community forests of northern and northeastern Thailand (Offenberg, 2011; Julapak *et al.*, 2016; Kaewnarin *et al.*, 2016).

Productivity of the major NTFPs at the sub-district scale

Each of these three principal types of NTFP had different occurrence periods, as shown in figure 2. The occurrence period is the period during which NTFPs provide their edible parts (*M. suavis* and edible mushrooms) or reach the edible stage (*O. smaragdina*). *M. suavis* produced its new buds and leaves in the warm and dry season, while *O. smaragdina* produced its queen broods from the end of the cool and dry season in January until the end of the warm and dry season in May. Most of the edible mushrooms developed their fruiting body in the wet season from June to September. However, several species, such as *Russula virescens* (Schaeff.) Fr., were found from the late wet season in October to the early cool and dry season. The very small production of *Lentinus polychrous* Lév. occurred in the cool and dry season, from October to December.

The NTFP harvesting areas in Lainan's community forests covered 312 ha. The productivity of *M. suavis*, queen broods of *O. smaragdina*, and edible mushrooms at the sub-district scale were 2, 12, and 2 kg/ha/year, respectively. The *M. suavis* production was highest in May at 310 kg (figure 3a). Wild fires, which occur in these deciduous community forests at the end of the dry season, in April, stimulate *M. suavis* to produce new branches and leaves after shedding their burned leaves.

Sribandit (2007) reported that the larva of *O. smaragdina* start to transform (metamorphose) into adults in March and the number of queen broods then decreased until the end of the dry season in May. This decrease in the production of queen broods of *O. smaragdina* was seen in this study as soon as April, as shown in figure 3b.

The production of edible mushrooms was high in the wet season (June to October), but very low in the cool and dry season (November to February) (figure 3 c). Fifty-two edible mushroom species were harvested in the wet season (figure 4). *Macrocybe crassa* (Berk.) Peg. & Lodge, *Amanita princeps* Corner & Bas., and *Russula emetica* (Schaeff. ex Fr.) Pers. ex S.F.Gray were the three dominant species collected with the highest productivities of 0.46, 0.36, and 0.20 kg/ha/year, respectively. *L. polychrous* was an edible mushroom species harvested in the cool and dry season (figure 4). This species displayed a very low productivity (0.03 kg/ha/year) as it needs to grow on coarse wood debris (Karunaratna *et al.*, 2011), which are rarely found in community forests due to the prohibition of logging activities.

Productivity of the major NTFPs among villages

Larger community forests, located at the low and middle elevations, had a lower productivity of NTFPs but higher total volumes of production than upper community forests due to their size (table II). Small upper community forests belonging to villages 5 and 6 had a high productivity of *M. suavis* and edible mushrooms but a low total production. These two community forests have a high potential to increase their production of NTFPs if their size expands in the future.

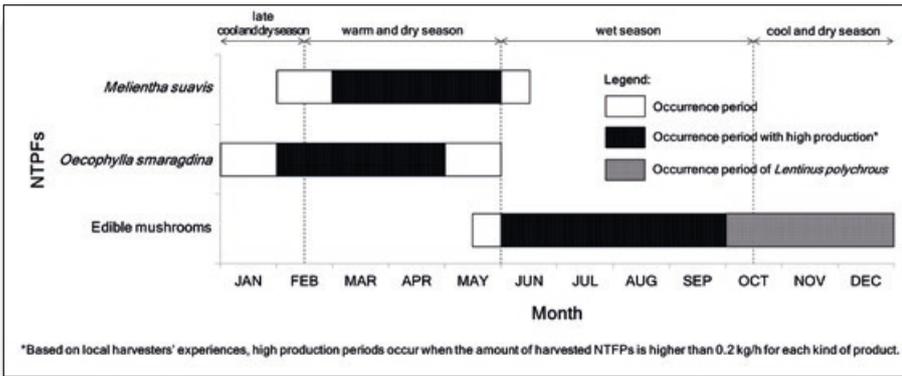


Figure 2. Occurrence periods of the three major NTFPs based on the local harvesters' experiences at Lainan Sub-district, Nan Province, northern Thailand.

No production of queen broods of *O. smaragdina* was found in upper community forests of villages 4-7. These community forests are surrounded by farm land and the use of insecticides in the neighboring fields may be one cause of this absence.

The NTFP harvesting pressure in the lower and middle community forests was high with more than 200 harvesters in each village (table I). Although they still provided a high production of NTFPs (table II), this is where the risk of future overharvesting exists. The upper community forests had a lower harvesting pressure because of their more difficult access and lower production of NTFPs.

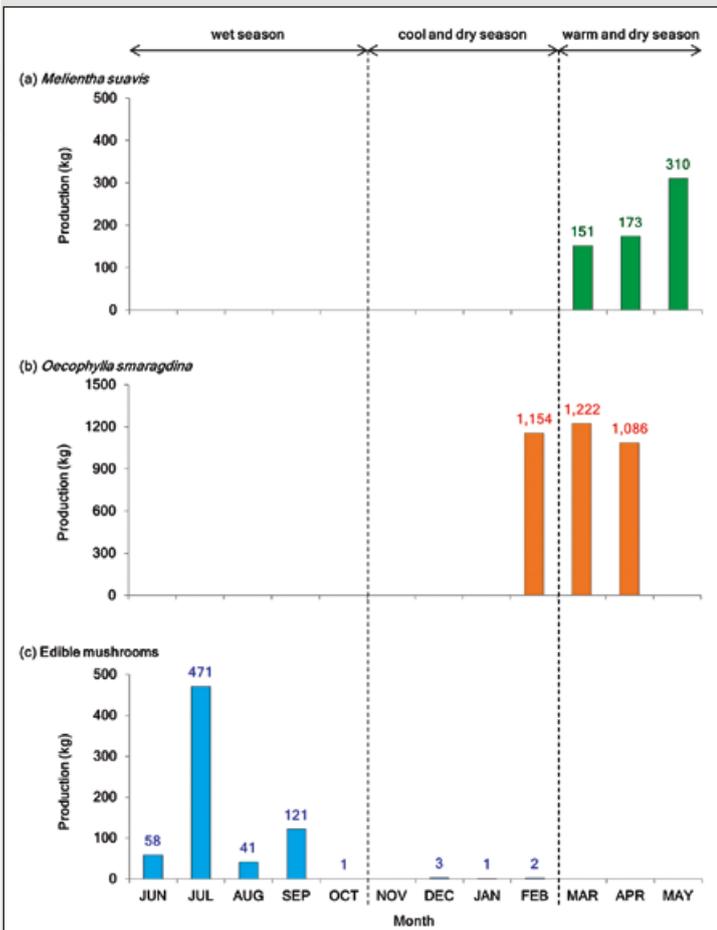


Figure 3. Monthly production of the three major NTFPs gathered from June 2015 to May 2016 at Lainan Sub-district, Nan Province, northern Thailand: (a) *Melientha suavis*, (b) queen broods of *Oecophylla smaragdina*, and (c) edible mushrooms.

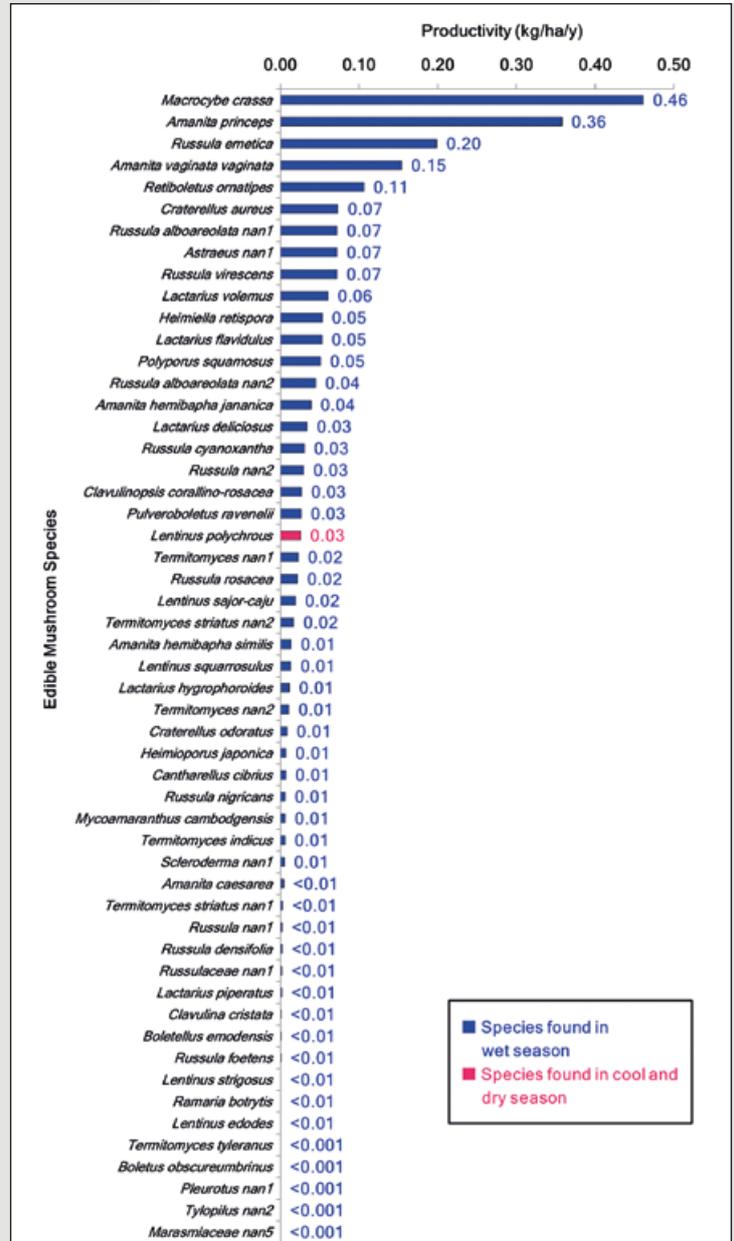


Figure 4. Productivity of edible mushroom species gathered from June 2015 to May 2016 at Lainan Sub-district, Nan Province, northern Thailand.

Table II.

Productivity (PT) and annual production (P) of the three major Non Timber Forest Products (NTFP) in each village of the Lainan Sub-district, Nan Province, northern Thailand.

NTFP species	P and PT	Village number and elevation*						
		1 Lower	2 Lower	3 Middle	4 Upper	5 Upper	6 Upper	7 Upper
<i>Melientha suavis</i>	PT (kg/ha/year)	5	1	2	7	12	13	3
	P (kg/year)	124	150	279	9	33	21	19
<i>Oecophylla smaragdina</i>	PT (kg/ha/year)	19	23	11**	n/a	n/a	n/a	n/a
	P (kg/year)	507	2,873	83	n/a	n/a	n/a	n/a
Edible mushrooms	PT (kg/ha/year)	1	1	3	3	12	27	11
	P (kg/year)	32	91	408	30	33	44	60
Total harvesting areas*** (ha)		27	125	139	12	3	2	6

*Elevation is defined as lower (≤ 280 m amsl), middle (> 280 , but ≤ 300 m amsl), and upper (> 300 m amsl). amsl: above mean sea level.

**Village 3 has six community forest patches. Local people usually gather NTFPs in the largest patch covering 139 ha. Since this largest patch provided a very low production of queen broods of *O. smaragdina*, another 8 ha patch was selected to estimate this production.

***Harvesting areas were defined as areas actually used to gather NTFPs. Some areas, e.g. cliffs, stream beds, or areas too distant from the village or with low productions, did not provide suitable conditions for harvesting NTFPs.

Table III.

Characteristics of the four types of NTFP harvesters at Lainan Sub-district, Nan Province, northern Thailand.

Criteria	Type of NTFP harvester				
	A. Landless villager	B. Small and medium landholder		C. Larger landholder	D. Outsider
		B1	B2		
Farm size (ha)	0	≤ 5.6	≤ 5.6	> 5.6	n/a
Importance of NTFP collection activity	High	Medium	Medium	Marginal	Varying
Purpose of collection	For sale	For sale	For self-consumption	For self-consumption	For sale
Harvest periods (months)	≥ 8	≤ 7	≤ 7	≤ 6	≤ 6
Overall volume harvested (in kg/year)					
<i>Melientha suavis</i>	≥ 128	≥ 16	≥ 6	≥ 4	n/a
Queen broods of <i>Oecophylla smaragdina</i>	≥ 128	≥ 8	≥ 2.4	≥ 0.4	n/a
Edible mushrooms	≥ 320	≥ 96	≥ 16	≥ 8	n/a

Typology of NTFP harvesters and their practices

Based on our survey, the NTFP harvesters could be classified into the four types as follows:

A. Landless villagers.

Their major source of income come from trading harvested NTFPs, so the economic survival of their livelihood system is strongly dependent on NTFP collection.

B. Small and medium landholders.

These households manage less than 5.6 ha of farm land. Beyond this farm size, the collection of NTFPs is limited as it becomes a minor activity for farmers carrying on their farms

larger than 5.6 ha. Most of the people in Lainan Sub-district belong to this type and they practice NTFP harvesting on a regular basis.

C. Larger landholders.

They managed more than 5.6 ha of farm land and are only marginally dependent on NTFP harvesting.

D. Outsiders.

These NTFP harvesters travel from other sub-districts, or even other provinces, to harvest NTFPs in the most productive lower and middle community forests of the Lainan Sub-district.

Table IV.
 Harvesting practices of the four types of NTFP harvesters at Lainan Sub-district, Nan Province, northern Thailand.

Type of NTFPs	Type of NTFP harvester				
	A*	B		C	D
		B1	B2		
I. <i>Melientha suavis</i>					
Harvest period	Feb-May	Mar-Apr	Mar-May	Mar-Apr	Mar-Apr
Harvest frequency (day/week)	4-6	2-3	1-2	1-2	n/a
Duration of harvest (hours/harvesting day)	3-4	2-3	2-3	1-2	n/a
Amount harvested (kg/harvesting day)	2.0-5.0	1.0-2.0	0.5-1.0	0.5-1.0	4.0-6.0
Amount used for self-consumption (kg/harvesting day)	0.2-0.3	0.5-1.0	0.5-1.0	0.5-1.0	n/a
II. Queen brood of <i>Oecophylla smaragdina</i>					
Harvest period	Feb-May	Mar-Apr	Mar-May	Mar-Apr	Mar-Apr
Harvest frequency (day/week)	4-6	1-2	1-2	2-3 days/month	n/a
Duration of harvest (hours/harvesting day)	2-4	2-3	2-3	< 1	n/a
Amount harvested (kg/harvesting day)	2.0-3.0	1.0-2.0	0.2-0.3	0.1-0.2	3.0-6.0
Amount used for self-consumption (kg/harvesting day)	0.2-0.3	0.2-0.3	0.2-0.3	0.1-0.2	n/a
III. Edible mushrooms					
Harvest period	Jun-Dec	Jun-Sep Oct-Dec (optional)**	Jun-Sep	Jun-Sep	Jun-Sep
Harvest frequency (day/week)	4-6	2-3	1-2	1-2	n/a
Duration of harvest (hours/harvesting day)	3-4	3-5	1-2	1-2	n/a
Amount harvested (kg/harvesting day)	4.0-5.0	3.0-5.0	1.0-2.0	0.5-1.0	5.0-10.0
Amount used for self-consumption (kg/harvesting day)	0.5-1.0	0.5-1.0	1.0-2.0	0.5-1.0	n/a
*Landless villagers could harvest NTFPs twice a day but the total duration of harvest and amounts of NTFPs harvested were estimated based on the sum of their daily harvesting trips.					
**During this period with a low production of edible mushrooms, some B1 type harvesters preferred to start harvesting annual crops on their farms.					

The characteristics of these different types of NTFP harvesters are presented in table III. Based on the purpose of harvesting, type B harvesters were split into the two sub-types of B1 and B2 harvesters who gathered NTFPs for sale and for self-consumption, respectively. Harvesters gathering NTFPs for sale (B1) consumed a share of the harvested products in the household and sold the remaining volume of products. The volume of NTFPs harvested by outsiders was not available because they could not be interviewed directly. The local regulations outlaw outsiders from gathering NTFPs in the community forests and so they generally stay away from people they do not know.

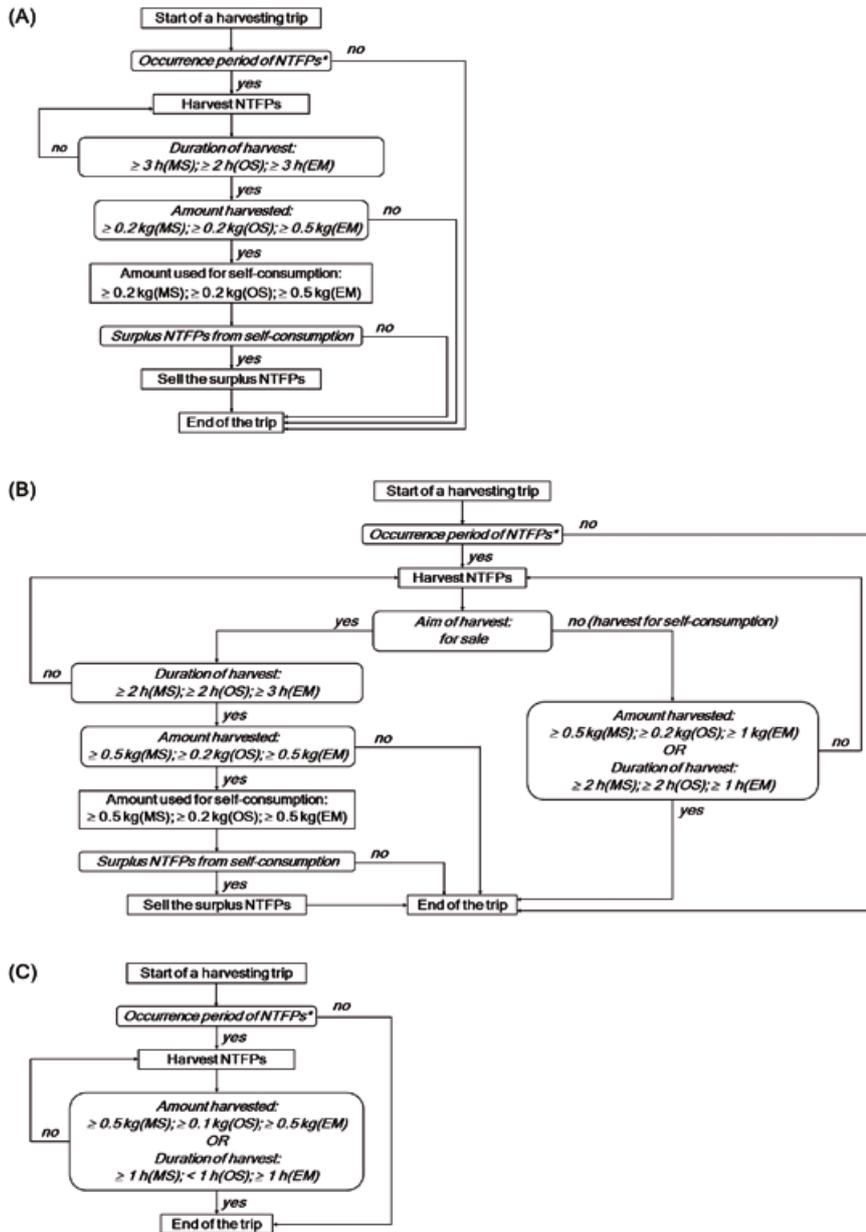
Table IV displays the different practices of these types of NTFP harvesters. Type A had the highest harvest frequency (day/week), duration of harvest (hours/harvesting day), and amount harvested (kg/harvesting day) among the local harvesters. The amount harvested by type A harvesters remained lower compared to outsiders, since the latter face higher costs and longer travelling times and so did their best to maximize the amount of NTFPs harvested per trip. The volume of *M. suavis* used for self-consumption by type A harvesters (0.2-0.3 kg/harvesting day) was lower than the other types because of the lower annual production of the

whole sub-district (635 kg/year), compared to queen broods of *O. smaragdina* and edible mushrooms, leading to a high market demand for *M. suavis*. The volume of queen broods of *O. smaragdina* used for self-consumption by type C harvesters (0.1-0.2 kg/harvesting day) was lower than the other types because of the shorter duration of harvest (less than 1 hour/harvesting day). As the annual cropping year starts in mid-April, type C harvesters with larger farms are busy preparing their land for cultivation and do not allocate much time to harvest queen broods of *O. smaragdina*. In case they need a higher volume of queen brood of *O. smaragdina*, they buy it from type A or B1 harvesters.

Decision-making processes of NTFP harvesters

Only the decision-making processes of types A, B, and C harvesters are presented in figure 5 as we could not collect such information from type D harvesters who avoid the interviews. The main parameters used by local harvesters to make their harvesting decisions were the occurrence period of NTFPs, the duration of harvest, and the amount harvested.

Type A harvesters decided to perform a second daily harvest when a large amount of NTFPs was available. That is



*The occurrence period of each kind of NTFP is shown in Figure 2.

Abbreviations: MS = *Melientha suavis*

OS = queen broods of *Oecophylla smaragdina*

EM = edible mushrooms

Figure 5.

Decision-making processes of the three types of NTFP harvesters at Lainan Sub-district, Nan Province, northern Thailand: (A) landless villagers, (B) small and medium landholders, and (C) larger landholders.

to say when the first harvest of the day was more than 2 kg for both *M. suavis* and queen broods of *O. smaragdina* and not less than 4 kg for edible mushrooms. Types B2 and C harvesters stopped gathering NTFPs when they had enough products for their self-consumption. When only a small amount of NTFPs were available, they stopped gathering NTFPs after spending more than one hour gathering them, depending

on which type of harvesters and what kind of NTFPs, as shown in (figure 5b and 5c), even if they could not collect enough products for their self-consumption needs.

Discussion

Differences in NTFPs productivity among villages

This study clearly showed that the productivity of *M. suavis* in the upper community forests was higher than the productivity in the lower and middle community forests (table II). The growth and development of *M. suavis* in natural forest ecosystems is dependent on the availability of shading, water, and nutrients from its surrounding host plants (Amprayn *et al.*, 2013). Unfortunately, no studies are available in the literature so far to understand the influence of host plant species on the growth rate, particularly shoot development, of *M. suavis* in Thailand or even in South East Asia.

Lokkers (1990) stated that the rainfall, temperature, and forest components had a strong influence on the production of *O. smaragdina*'s queen broods. The development of the queen brood is particularly sensitive to low temperature with a threshold of 16.8 ± 0.7 °C. However, in this study, temperature is less important than rainfall as the mean daily temperature at Nan Province is always above 16.8 °C (Meteorological Department, 2019). The community forests of villages 1-3 were close to each other in a similar area characterized by a very similar forest tree structures (a mixture of dry dipterocarp and mixed deciduous forests in village 1; and dry dipterocarp forests in villages 2 and 3). This suggests that rainfall and temperature did not differ significantly among these three

community forests. Taylor and Adedoyin (1978) reported that *O. smaragdina* only inhabited areas of high tree density with interconnecting canopy, so a likely explanation for the differences in productivity of *O. smaragdina*'s queen brood among these three villages could be the influences of tree density and canopy cover, but additional studies will be needed to confirm this.

Numerous interacting factors and conditions influence wild mushroom yields and include environmental (rain-fall, air and soil temperatures, evapotranspiration, relative humidity, and water deficits or excesses), silvicultural (tree species, stand age, density, distribution, and canopy cover), ecological (community composition, competitive interactions, and reproductive strategies), landscape (altitude, aspect, and slope), and anthropogenic (timber removal, controlled burns, wildlife management strategies, grazing, and introduced species) factors (Martínez de Aragón *et al.*, 2007). Weather conditions clearly played a key role in relation to the growth and productivity of mushrooms at our research site, but it was not possible to conclude which combined factors interacted with the productivity of edible mushrooms at completion of such a short-term study (Egli, 2011). Interestingly, most edible mushrooms in this study (at least 35 out of the 53 species) were ectomycorrhizal fungi (Tedersoo *et al.*, 2010), which are a symbiotic relationship between the soil fungi and the fine roots of their respective host trees (mostly belonging to Dipterocarpaceae). The dominant tree species in Lainan's community forests were *Shorea obtuse* Wall, *Shorea siamensis* Miq., *Quercus* sp., and *Dipterocarpus obtusifolius* Teijsm. ex Miq., which are host trees for ectomycorrhizal fungi. Further longer-term and in-depth studies are needed to examine the factors related to mushroom productivity and the influences of such host trees on the yields of ectomycorrhizal mushrooms.

Level of NTFPs productivity

Sribandit (2007) reported that the productivity of *O. smaragdina*'s queen broods was only 0.59 kg/ha/year, but in our study the productivity at the whole sub-district level was much higher (20-fold) at an estimated 12 kg/ha/year. However, Sribandit (2007) examined a large heterogeneous area of 78 km² in northeastern Thailand, which was only partly used for NTFP harvesting and was composed of natural deciduous dry dipterocarp, dry evergreen and disturbed forests due to urbanization, as well as plantations and orchards. In our study, the field data collection was conducted in much smaller areas of dry dipterocarp and mixed deciduous forests covering only 312 ha. These areas were less heterogeneous (with respect to the types of forest and land-use activities) and covered only NTFP harvested areas leading to the higher productivity.

Chanopas *et al.* (2006) identified more than 123 edible mushrooms species in a natural forest ecosystem of northern Thailand, far more than the 53 species found in this study. Most natural forest ecosystems in Thailand are protected under the law and NTFP harvesting is not permitted, but it is not illegal in community forests. Harvesting of NTFPs affects ecological processes at both individual and population levels, such as changes in the survival rate, growth, and reproduction of harvested NTFPs (Ticktin, 2004). At Lainan's community forests, some damage while gathering NTFPs occurred occasionally due to the harmful practices of outsiders, such as using a small rake (called "waek" in the local language) to search for *Astraeus nan1* on the forest ground. This practice destroys the mushroom sporophytes

prior to spore release leading to a potential decline in the mushroom species diversity. However, Kullama and Sinunta (2011) reported similar numbers of edible mushrooms (54 species) found in the central markets of 11 districts in Nan Province. These species were probably the only ones with high market value, while the other species may be collected for local harvesters' household consumption only.

No data are available in the literature to compare the productivity of *M. suavis* with other case studies and our survey is filling a knowledge gap here. The availability of such quantitative data for the three major NTFPs is very important to monitor and evaluate existing management practices, or to support the design of an environmental conservation policy (Ticktin, 2004; Schulp *et al.*, 2014).

NTFPs support for resource-poor households

The community forests at Lainan Sub-district have been continuously encroached during the past 30 years (table I). In the case of landless villagers, NTFPs are harvested continuously for eight months, from February to September (figure 3), and provide these resource-poor families with regular cash income during this period while satisfying part of their basic household consumption needs. During the remaining four months, corresponding to the harvest period of key crops (maize, rice, etc.), their family workers generate further cash income through wage-earning activities carried out on larger type C farms.

Access to NTFPs and perspectives

In recent years, most young villagers have moved to live and work outside of the villages after completing their secondary education and so currently by and large only middle-aged and old harvesters still gather NTFPs in the community forests. Consequently, indigenous knowledge, especially dealing with the differentiation of edible from poisonous mushroom species, could vanish in the near future.

Some studies found that NTFP harvesting can negatively affect ecological processes at many levels, particularly at the local community one (Ticktin, 2004). Several countries, especially European countries, such as France and Italy, authorize and regulate NTFP harvesting with a permit allowing the gathering of a limited amount of products. Such types of regulation can be used to control not only individuals, but also the collective access of harvesters to NTFPs (Górriz-Mifsud *et al.*, 2017). In lower and middle community forests (villages 1-3), local people have been attempting to prevent outsiders from harvesting NTFPs in their community forests for many years to prevent overexploitation. A harvesting permit may be used to regulate the number of harvesters as well as the periods and frequency of harvesting visits to decrease the pressure on these resources. This could be an innovative conservation practice to be tested with local stakeholders (all types of harvesters, village headmen, CFM committees, SAO, other villagers, and researchers) at the sub-district scale as part of a subsequent collaborative action-research process, particularly to assess the feasibility of its enforcement at the site in a participatory way.

Such an action-research process would support knowledge exchanges among stakeholders and facilitate the exploration of different scenarios of suitable and socially acceptable rules and regulations for further improving the sustainable management of NTFP harvesting in local community forests.

Conclusion

Three major types of NTFPs could be harvested in succession from February to September in community forests: queen broods of *Oecophylla smaragdina* from February to April, *Melientha suavis* from March to May, and edible mushrooms from June to September. Their productivity at the whole sub-district was 2, 12, and 2 kg/ha/year for *M. suavis*, queen broods of *O. smaragdina*, and edible mushrooms, respectively.

We identified four types of harvesters as (A) landless villagers, (B) small and medium landholders, (C) larger landholders, and (D) outsiders with different harvesting practices. The three types of local harvesters displayed different decision-making processes to gather NTFPs depending on the three parameters of the occurrence period of resources, the duration of harvest, and the amount harvested. Landless type A harvesters practiced a longer harvesting duration and harvested a higher amount, as the survival of their livelihood system still depended very much on this activity.

The original data provided by this survey, implemented to fill knowledge gaps on the production and productivity of NTFPs, as well as the harvesters' practices and decision-making regarding gathering of NTFPs, will be used in a subsequent collaborative action-research process. Based on the field results reported in this article, it will be designed to stimulate knowledge exchanges among heterogeneous local NTFPs stakeholders. It will also aim at exploring acceptable and appropriate collective rules and regulations to sustain the production of key NTFPs in the local community forests.

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Appendix 1.

Specific questions of the semi-structured guideline used with NTFP harvesters in preliminary surveys.

1- Basic information of the informant (name, surname, sex, age, occupation, income, the number of member(s) in a family)

2- NTFPs found in the community forests, and their occurrence period and farm gate price

How frequently do you collect NTFPs in the community forests?

What are the NTFPs that can be found in the community forests and which part(s) of these NTFPs is (are) collected?

In harvesting these NTFPs, do you (need to) use any special equipment?

What is (are) the occurrence period(s) of these NTFPs? How do these NTFPs change in their productivity during the occurrence period(s)? Which NTFPs can be sold and what is(are) the farm gate price(s) of these NTFPs?

3- History and evolution of the community forestry

Did you know/Did your parents or grandparents tell you about stories of foundation of the community forests and why were the forests founded?

What is the evolution of the forestry management (any significant changes, such as turning over the leader(s) or CFM committee reaching to better or worse management practices)?

4- CFM rules and regulations, and current CFM problems

Are there any written rules/regulations for CFM? If yes, where is it?

What did you (best) remember in details of these rules/regulations?

Who created these rules/regulations (leaders only, local villagers only, or both leaders and local villagers)?

How long ago were these rules/regulations used in the CFM?

During the past 10 (or 5) years, were there any cases of breaking the rules/regulations? If yes, did the punishment(s) taken follow these rules/regulations?

Currently, are there any problems in CFM? If yes, can you clarify?

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