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Harvest and trade of wild edible *Russula griseocarnosa* in North Vietnam

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ABSTRACT
This study examines the harvest and trade of wild edible *Russula griseocarnosa* in north Vietnam. *Russula griseocarnosa* is an edible forest mushroom, but there is no reliable information on harvesting practices and trade in this species in Vietnam. This study aims to provide ethnomycological and marketing knowledge for this mushroom. Semi-structured interviews were conducted with mushroom collectors and traders over 2 years; harvest yields were obtained from local officials; and policy settings were sought from forest managers. About 85% of mushroom collectors were women of the Dao, Lo Ursula, Muong, Nung, Mong, San Chi, San Diu, and Tay ethnicities. The collecting season was bimodal, with the wet season beginning (May) and ending (September). The traders were Hoa, Kinh, Nung and Tay, and 57% were women. Fresh mushrooms sold for 9.1-10.5 US$/kg on dry days and 7.0-7.9 US$/kg on wet days. The best grade of dried product fetched 70.4-83.3 US$/kg. A number of interim policies have been established to encourage local people to protect forests and to help create a sustainable edible wild mushroom market. Our study provides the first detailed account of the role of edible wild mushrooms in northeast Vietnam, and this will inform the co-development of rural livelihood and sustainable forest management plans.

Contribution/Originality: *Russula griseocarnosa* is a nutritious and popular wild edible mushroom in southern China and northern Vietnam. However, there is no information on harvesting and trade of this wild edible mushroom in Vietnam. The research gap filled by this paper will assist in developing the market chain and mushroom product opportunities of *Russula griseocarnosa* in Vietnam.

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1. INTRODUCTION
Many people in rural areas depend on forests for their livelihoods, and this is emphasized in Sustainable Development Goal 15 (FAO, 2015). In particular, non-timber forest products (NTFPs) contribute significantly to the welfare of rural communities in many parts of the world (Dao & Hölscher, 2018; Epanda et al., 2020; Shackleton & Shackleton, 2004; Silva et al., 2020). In Asia, over 300 million people rely fully or partly on NTFPs for their subsistence (Dao & Hölscher, 2018; Pandey, Tripathi, & Kumar, 2016), and forests are an important source of food for local people. From an analysis of households in 24 developing countries, Hickey, Pouliot, Smith-Hall, Wunder, and Nielsen (2016) found that forests were the predominant location for the generation of income from wild food. Furthermore, people

harvest hundreds of species of edible wild mushrooms from forests, many of which have cultural significance (Boa, 2004; Brown, 2019; Mortimer et al., 2012; Yu, Guerin-Laguette, & Wang, 2020; Yusran, Erniwati, Khumaidi, Rukmi, & Sustri, 2024).

Local markets have been trading edible wild mushrooms for centuries, primarily to meet the needs of indegineous people (Satyanarayana, Das, & Johri, 2019; Srikram & Supapvanich, 2016; Verma, Pandro, Mishra, Raj, & Asaiya, 2019). However, in recent decades, the demand for some species has rocketed in international markets, leading to the overharvesting and depletion of natural resources (Yamada, 2022). The development of mycotourism and mycogastronomy has further expanded the market for edible mushroom species (Barroetaveña & Pildain, 2022). Many wild edible mushrooms fruit in association with particular forest trees, where they form symbiotic ectomycorrhizal associations (Sanmee, Dell, Lumyong, Izumori, & Lumyong, 2003). Without the presence of host tree, cultivating the majority of these fungi for food is impossible.

A wide diversity of forest mushrooms are being harvested for food across upland Asia (Dell et al., 2000; McLellan & Brown, 2017), and this is well documented for high-value fungi such as truffles and matsutake (He, Dong, & Stark, 2014; Wang et al., 2022). There are however no detailed accounts of the collection and trade in *Russula* species, even though they are widely reported in local and city markets (Buyck, 2008; Łuczaj et al., 2021; Panda & Tayung, 2015; Sanmee et al., 2003; Shirai & Rambo, 2014).

The ectomycorrhizal *Russula* genus has a global distribution and contains a number of sought-after edible species with good flavor and nutritional value when cooked (Ijioma Blessing, Ihediohanma Ngozi, Onuegbu Ngozi, & Okafor Damaris, 2015; Kaewgrajang, Kaewjunsri, Jannual, & Nipitwattanaphon, 2020; Nadjombé et al., 2022). Rural communities in Asia collect some species for domestic consumption and for processing into commercial products (Atri, Sharma, Kumar, & Mridu, 2019; Chen, Xia, Zhou, & Qiu, 2010; Shiyan, Tianyan, Bin, Fuchang, & Xiaohua, 1998). There are eight edible species of *Russula* in Vietnam (Anh et al., 2023; Kiet, 2012; Nguyen, 2017; Phu & Kiet, 2019), of which *Russula griseocarnosa* (nấm chẹo) is most commonly used for food (Anh, Chi, & Dell, 2024; Anh et al., 2023), traded in local markets, and exported (Chi, 2022; Quang Ninh, 2020). The mushroom has an attractive dark pink to red pileus, 8-13 cm in diameter, which is bellshaped when young, becoming hemispherical, and flat or slightly sunken in the centre when mature; and the flesh is firm and white (Anh et al., 2023). It fruits under wild *Castanopsis*, *Engelhardia*, and *Lithocarpus* trees in mixed forests in northeast Vietnam (Anh et al., 2023; Chi, 2022). *Russula griseocarnosa* was first described by Wang, Yang, Li, Knudsen, and Liu (2009) from collections made in southwestern China, where it is valued as an edible mushroom with high nutritional value (Anh et al., 2024; Chen et al., 2010; Ming, Li, Huo, Wei, & Chen, 2014).

Unlike in neighboring Yunnan, where there are many studies on the harvesting and use of edible ectomycorrhizal fungi, the ethnomycology, use, and trade of forest mushrooms have not been investigated in any depth in Vietnam. Even so, the Ministry of Agriculture and Rural Development as well as local entities are starting to promote further commercialization of the wild mushroom market. Nevertheless, progress is constrained by a limited understanding of the ethnic groups engaged in collecting and trading, and the relative importance of wild mushrooms in the rural economy. Therefore, this study on *Russula griseocarnosa* was undertaken to: (i) determine the extent that rural households engage in the collection of *Russula griseocarnosa*; (ii) identify the value chain and existing market for *Russula griseocarnosa*; and (iii) scope out relevant government policies. Data obtained on *Russula griseocarnosa* can assist policy development and more in-depth research on sustainable rural development in Vietnam.

2. STUDY REGION AND METHODOLOGY

2.1. Study Region

Bac Giang, Cao Bang, Lang Son, and Quang Ninh provinces (Figure 1) in northeast Vietnam were chosen for this study because local people have a long tradition of using wild mushrooms for food (Anh et al., 2023). In these provinces there are established markets for *Russula griseocarnosa*, including local markets, restaurants using this mushroom, and traders who export dried mushrooms to China. These four provinces have a relatively high (51-64%) cover of primary and secondary, wet evergreen sub-tropical forests. The upland forests contain tree species within the Fagaceae and Juglandaceae, which can form symbiotic ectomycorrhizal associations with higher fungi, including species of edible forest mushrooms such as *Russula*. About 1.9 million people live in this part of Vietnam, and over 60% are farmers. The ethnic composition includes Dao, Hoa, Kinh, Lo Lo (Lo Ursula), Muong, Nung, Mong, San Chi, San Diu, and Tay people. The livelihoods of farmers are mainly based on the cultivation of agricultural crops such as rice, corn, and cassava, and the harvesting of NTFPs. This is a relatively poor part of Vietnam where the disposable income of rural people is about 1,400-1,600 US$/person/year (Anonymous, 2022).

2.2. Methods

2.2.1. Harvest, Market and Trade Interviewees

Quantitative and qualitative data were obtained on the harvesting and trade of wild *Russula griseocarnosa* from interviews undertaken with mushroom collectors, mushroom traders, forest managers, and market regulators. The locations of *Russula griseocarnosa* collecting sites and names of villages and towns involved in the marketing and trade of fresh and dry basidiomes were obtained from forest managers of each community in Bac Giang, Cao Bang, Lang Son, and Quang Ninh provinces. Forest managers and forest rangers of each community provided the names of all individuals involved in *Russula griseocarnosa* harvesting. All restaurants at the survey locations were included in the interview process. Mushroom traders include those who on sell fresh mushrooms that they have purchased in local

markets; those who buy fresh mushrooms directly from collectors to on sell, use as food in their restaurants, or dry and sell to other traders; and other traders who only deal in the dried mushrooms for domestic and export markets.

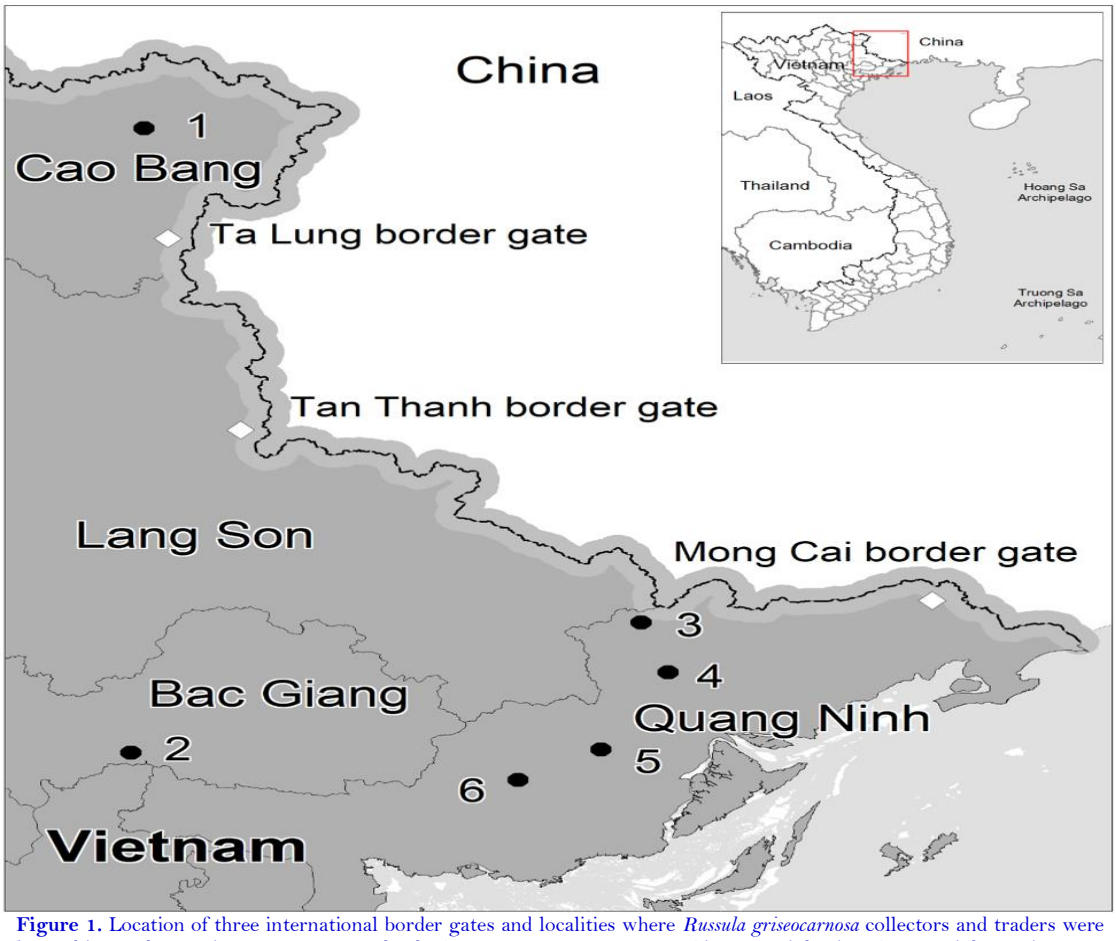

Figure 1. Location of three international border gates and localities where *Russula griseocarnosa* collectors and traders were located in northeast Vietnam: 1. Trung Khanh, Cao Bang; 2. Luc Nam, Bac Giang; 3. Binh Lieu, Quang Ninh; 4. Tien Yen, Quang Ninh; 5. Ba Che, Quang Ninh; 6. Ha Long, Quang Ninh.

2.2.2. Interview Process

Primary data on *Russula griseocarnosa* collecting, market consumption, and trading of products were obtained from interviews (Table 1). Interviews were conducted in November 2021 with 84 *Russula griseocarnosa* collectors (18 were also traders in local markets), 51 traders (21 owned restaurants), and 20 forest managers. Follow-up information on mushroom prices and volumes collected was obtained in a second interview conducted in June or December 2022. The survey in 2022 included an additional 4 collectors. Most of the collectors (90%) were interviewed in their homes, and the remainder were interviewed in the field whilst collecting. The traders comprised 15 shopkeepers in three border markets (Ta Lung, Tan Thanh, and Mong Cai international border gates, Figure 1), 33 traders at local markets, and 21 traders at restaurants.

Table 1. The categories and number of people interviewed for the edible *Russula griseocarnosa* field collection and market survey.

Category	Location				Notes
	Home/ Forest	Local market	Restaurant	Local government	
Collector	70	18	0	0	In 21 villages belonging to six districts (Figure 1): 4 villages/District in Quang Ninh, 1 village in Luc Nam and Bac Giang, 4 villages in Trung Khanh and Cao Bang; 4 collectors/Village in Quang Ninh and Cao Bang, 8 collectors in Bac Giang. The number of collectors per ethnicity: Dao (12), Lo Lo (8), Muong (10), Nung (16), Mong (8), San Chi (9), San Diu (7), Tay (18)
Trader	0	30	21	0	18 in 12 villages (11 Tay, 7 Nung) and 33 in 8 towns (12 Hoa, 10 Kinh, 6 Tay, 5 Nung) belonging to 6 districts and 3 border gates (Figure 1)
Forest manager	0	0	0	20	5 districts, 3 provincial cities, 10 wards, and 2 towns in Bac Giang, Cao Bang, Lang Son and Quang Ninh provinces, one person in each location

The interview questions were formulated, discussed, and agreed upon by the members of the research team (Supplementary Data 1-4), and the four interviewees received training through group discussion. Interviews were conducted using standard protocols. The purpose of the interview was explained, participants were informed that the information provided will be used for scientific purposes, consent was required by the interviewee, and interviews were coded to protect the anonymity of participants. The interviews were semi-structured and open-ended with questions about origin, season, preparation, intended use, quality, price, and consuming address (Supplementary Data 1-3). Face-to-face interviews ranged from 30 to 40 minutes, notes were taken, and audio recordings were made with the participants' consent. All of the 159 interviewees were Vietnamese, and interviews were therefore conducted in Vietnamese. Information from the interviews, recordings, and notes was translated from Vietnamese to English. The data were coded manually to identify core issues, and then grouped into main themes. This work was done independently and checked by two members from Quang Ninh Department of Science and Technology based on the requirement for undertaking interviews within the Vietnamese Academy of Forest Sciences.

2.2.3. Policy Setting

To obtain primary data on the development of policy for *Russula griseocarnosa* in northeast Vietnam, written questions were sent, one person per organization, to the Department of Forestry, the Department of Crop Production within the Ministry of Agriculture and Rural Development (MARD), and the Department of Agriculture and Rural Development in Bac Giang, Cao Bang, Lang Son and Quang Ninh provinces. The questions covered any policies regarding the harvesting, processing, and trade of *Russula griseocarnosa* as well as future management directions for this species (Supplementary Data 4).

2.2.4. Data Analysis

The age and sex distribution of *Russula griseocarnosa* collectors and traders were compiled. Data for fresh weights of harvested *Russula griseocarnosa* were obtained from local officials - mushroom collectors are required to self-report their daily harvest in these provinces. These data were used to calculate the monthly fungal biomass harvested over a two-year period. Data obtained from interviews for the price of fresh and dried mushrooms were appraised using box plots (Microsoft Excel version 2021).

3. RESULTS AND DISCUSSION

3.1. Mushroom Collectors

Information on ethnomycology was collated over two years from semi-structured interviews with 88 mushroom collectors. The *Russula griseocarnosa* collectors belonged to 8 ethnic groups, namely Dao, Lo Lo, Muong, Nung, Mong, San Chi, San Diu, and Tay (Table 2). The greatest number of mushroom collectors were women (75 people, >85%) with mean age of 41.5 years (range 26.2-61.5 years) (Figure 2, 3b). Only 13 of the collectors were men, and they comprised an older cohort (mean age 61.4, range 55.1-66.3 years). No children collected mushrooms. Overall, only about 5-6% of the local population participated in harvesting *Russula griseocarnosa*. Collectors traveled on foot or motorbike up to 3-5 km from their homes to access forested lands containing the ectomycorrhizal hosts within the walnut (Juglandaceae) and beech (Fagaceae) families (Anh et al., 2023). They identified edible mushrooms using local indigenous knowledge, which they passed on their family's descendants and occasionally to other community members. The *Russula griseocarnosa* fruiting bodies were pulled up by hand and transported in bamboo or plastic baskets back to the villages. Ethnic communities located further away from the *Russula griseocarnosa* forests engage in other NTFP activities such as collecting bamboo shoots, honey, and medicinal plants (Thao, 2017).

Table 2. Main findings from survey questions regarding the harvesting and trade of *Russula griseocarnosa* from forests in northeast Vietnam.

Survey question	Finding
When are the main collecting times?	✓ Daily collecting times: 04:00-06:00 h. ✓ Collecting seasons: April to June and August to October ✓ Frequency of collection: There are about 6-8 mushroom fruiting events per year, each lasting 3-5 days
Gender of collectors and traders?	✓ Collectors: Most (>85%) are women ✓ Processors and traders: Nearly equal proportions of men and women
Amount gathered per person?	✓ Each collector can earn 10-25 US$ for each day of mushroom harvesting ✓ During these times, the value derived from mushroom harvesting can cover 6-18% of their family's economic needs ✓ About 15-20% of the collected mushrooms is used for food, the remainder is sold to traders
Who trades in the fresh mushrooms?	✓ Some collectors sell mushrooms at their local market ✓ Traders at local markets, restaurant owners and traders buy fresh mushrooms for drying
Who trades in the dried mushrooms?	✓ Traders at local markets, restaurant owners ✓ Traders at the markets at the border gates with China
What ethnicities are involved?	✓ Harvesters: Dao, Lo Lo, Muong, Nung, Mong, San Chi, San Diu, and Tay people. ✓ Traders: Hoa, Kinh, Nung, and Tay people
Who keeps the knowledge and how is it handed down?	✓ People used indigenous knowledge to identify edible mushrooms and distinguish them from poisonous mushrooms ✓ They passed their knowledge to their descendants in their families and communities

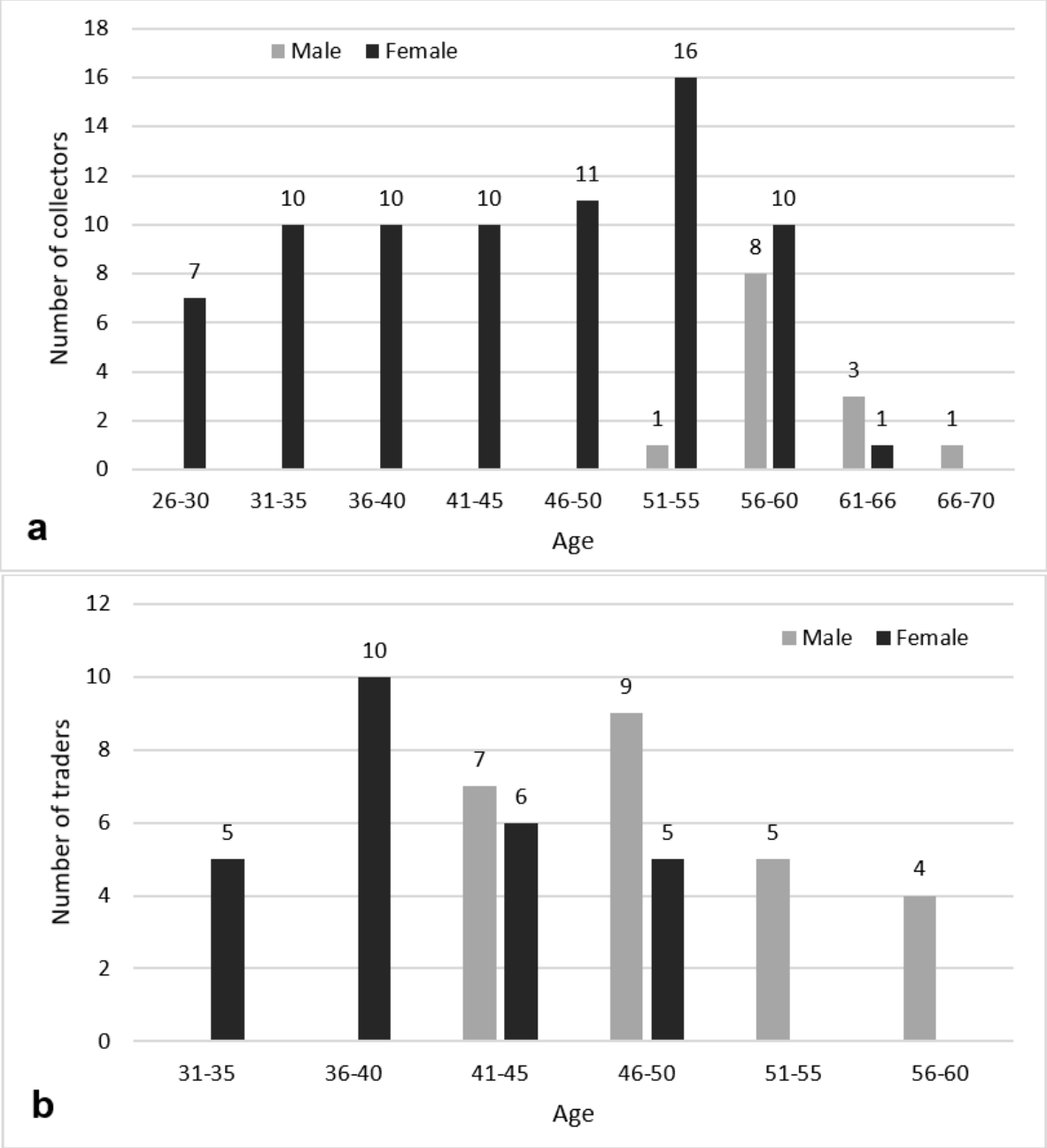

Figure 2. Distribution of the number of *Russula griseocarnosa* collectors and traders by age and sex: a. Mushroom collectors; b. Mushroom traders.

Ireson (1996) observed that Khmu and Hmong women gathered mushrooms in rural Laos. Also, in Pu'er Prefecture in Yunnan, Wang et al. (2022) showed that people aged 45-65 had more experience with wild edible mushrooms than other age cohorts. There are considerable differences between cultures in the extent to which rural women engage in NTFP mushroom activities. In contrast to the study, Wang et al. (2022) found that men often possessed more knowledge about mushrooms than women. In our study, over half (57%) of the mushroom traders were women, whereas in the Guatemalan Highlands women exclusively sold mushrooms in the local markets (Mérida Ponce, Hernández Calderón, Comandini, Rinaldi, & Flores Arzú, 2019). It will be intriguing to extend our study to determine if the ethnic groups collecting *Russula* in Vietnam share mushroom harvesting practices with nearby countries. For example, the Dao, Hoa, Lo Lo, Nung, and San Diu people have language connections to China, and Wang et al. (2022) reported that the Yi people (Lo Lo in Vietnam) collect *Russula* in Yunnan. Also, there are some ethnicities collecting *Russula* in Vietnam who belong to language groups from nearby countries in SE Asia.

Interviews with forest managers revealed that they all had a common interest in encouraging the development of NTFPs through technical and financial support. Forest managers supply permits to people living in an adjacent forests where *Russula griseocarnosa* occurs, allowing them to enter the forests for mushroom collection. However, the impact of harvesting on the forest ecosystems is unknown, and it is uncertain whether the current harvesting pressure is sustainable. This is a concerning because there is local government pressure to expand the wild mushroom trade. In particular, forest managers are encouraging mushroom collectors to share their knowledge of *Russula griseocarnosa*

within the community. The provincial level is gathering some data on NTFP products, but it does not separate them by different ethencities.

3.2. Harvest Season

Figure 4. illustrates monthly *Russula griseocarnosa* harvest yields and weather records. Each year there were two seasons for collecting *Russula griseocarnosa:* April to June and August to October. No mushrooms were collected in July, the month with the highest rainfall and maximum temperature. According to collectors, there were 6-8 concentrated mushroom fruiting events in each collecting season. Harvesting took place early in the morning, from 04:00 to 06:00 h. Proceeds from the sale of fresh *Russula griseocarnosa* by collectors contributed about 15-18% to their family income (equivalent to about 80-90 US$/month) during peak collecting months, May and September (Table 2).

Figure 3. Edible *Russula griseocarnosa* fruiting bodies: **a**. Young specimen; **b**. Collecting mushrooms in secondary forest, the two women standing are indigenous harvesters; **c**. Old specimens; **d**. Dried sliced mushrooms; **e**. Cooked mushrooms in chicken soup; **f**, **g**. Dried mushrooms in the markets, loose (f) and in sealed plastic bags (g).

Russula griseocarnosa fruiting was bimodal, corresponding to the shoulders of the wet season when air temperatures were moderate, being 21-28 oC in May and 24-31 oC in September, compared to 26-33 oC in July (data from the Vietnam Meteorological and Hydrological Administration). A bimodal pattern of mushroom fruiting was also observed by Christensen (2009) in a *Schima-Castanopsis* forest in Central Nepal. In general, temperature and precipitation strongly influence the season of fruiting of higher fungi (Parmesan, 2007), but rainfall is less important in tropical than temperate forests (Li et al., 2018). In the central and southern parts of Vietnam, other *Russula* spp. collected for food also fruit in the wet season (Kiet, 2012; Nguyen, 2017; Phu & Kiet, 2019), but whether fruiting is unimodal or bimodal has yet to be determined.

3.3. Sorting and Drying

After harvesting, the mushrooms were sorted into two categories. Lower-quality mushrooms with fully opened or cracked caps (about 15-20%, Figure 3c) were either used by the collectors for food (Figure 3e; about 15-20% of the fresh mushrooms collected) or sold at local markets on the day of collection to families that did not gather mushrooms to use as food. Higher-quality mushrooms with ovoid or unopened fruiting bodies (Figure 3a) were mainly sold to traders for drying. A minority of collectors (18) also dried some of their fresh mushrooms. The fresh mushrooms were roughly divided by hand into pieces and placed in a single layer on mesh shelves inside sheet metal boxes 1.6 m × 1.0 m × 2.5 m (length × width × height). Five to six stoves using coal briquettes provided bottom heat. Drying took about 20-24 hours, yielding 6-10 kg of dried mushrooms per chamber. About 6-7 kg of fresh mushrooms produced 1 kg of dried mushrooms. The dried mushroom pieces (Figure 3f) were stored in plastic bags (Figure 3d, g) or in plastic boxes to exclude moisture and pests.

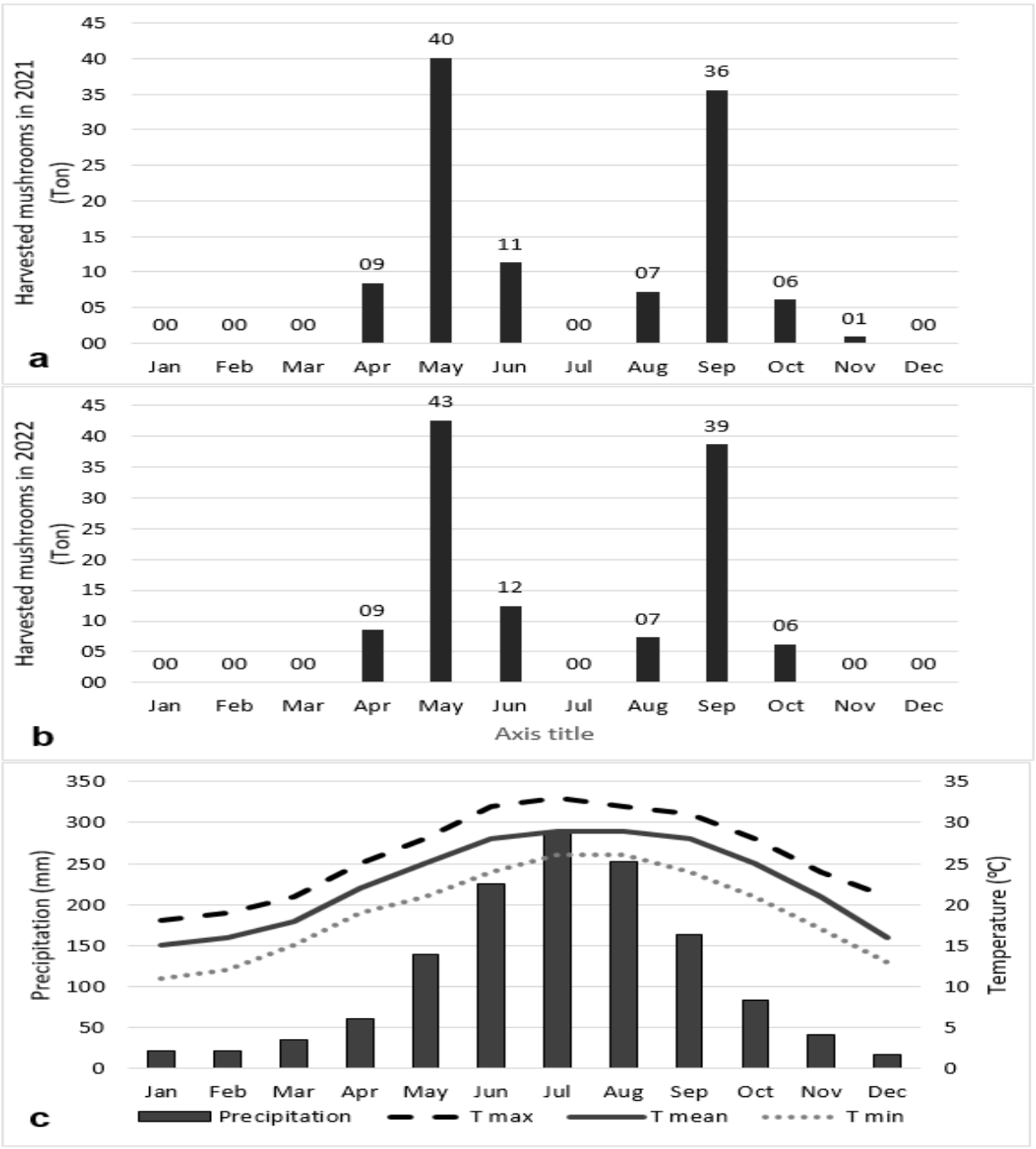

Figure 4. Distribution of collecting times of *Russula griseocarnosa* across the year: **a**. Total weight of fresh mushrooms harvested in the four surveyed provinces in 2021; **b**. Total weight of fresh mushrooms harvested in the same provinces in 2022; **c**. Average temperature and precipitation of northeast Vietnam.
Source: vnmha.gov.vn/nchmf-new/show-city-weather, accessed August 19, 2023.

3.4. Trade

The traders interviewed had been dealing in *Russula griseocarnosa* for at least 5 years. They comprised 29 women with mean age of 44.2 years (range 31.1-50.1) and 22 men with a mean age of 45.8 years (range 42.3-60.2). The 18 collectors who also traded were either Tay (11) or Nung (7) and they lived in local villages. The remaining 33 traders lived in towns, and they comprised four ethnicities (Table 1). The Hoa and Kinh people generally have more capital and trading experience than the other ethnicities (Chi, 2022; Thao, 2017), and they do not partake in mushroom

harvesting. Table 3 summarizes the data synthesized from interviews. Trade in *Russula griseocarnosa* in northeast Vietnam included fresh and dried mushrooms (Figure 3b, d). The price of fresh mushrooms obtained from 117 responses ranged from 7.1-10.4 US$/kg (average 8.6±1.27 US$/kg), and for dried mushrooms (106 responses), the price was 52.1-83.3 US$/kg (average 61.9±17.86 US$/kg) (Figure 5). Young ovoid and partially open mushrooms (Figure 3a) were worth 15-20% more than fully open or cracked mushrooms (Figure 3c). Furthermore, *Russula griseocarnosa* collected in May (spring) and October (autumn) fetched higher prices than those collected in June-September (summer). Also, prices were higher on days without rain than days with prolonged rain. According to local government records, about 113 tons per year of fresh *Russula griseocarnosa* mushrooms were harvested in Cao Bang, Bac Giang, Lang Son and Quang Ninh provinces. There are no records of the weight of dried mushrooms consumed in restaurants, but about 10-12 tons are exported under quota to China, mainly from Quang Ninh province.

Table 3. The fresh and dried *Russula griseocarnosa* market in northeast Vietnam over 2021-2022.

Province	Product	Use	Price (US$/kg)
Cao Bang	Fresh	Locally, traded within the province	7.5 - 9.2
	Dried	Domestic and export	52.1 - 72.9
Bac Giang	Fresh	Locally, traded within the province	7.3 - 9.9
	Dried	Domestic and export	54.6 - 70.4
Lang Son	Fresh	Locally, traded within the province	7.1 - 9.6
	Dried	Domestic and export	58.3 - 75.0
Quang Ninh	Fresh	Locally, traded within the province and between provinces	7.7 - 10.4
	Dried	Domestic and export	62.5 - 83.3

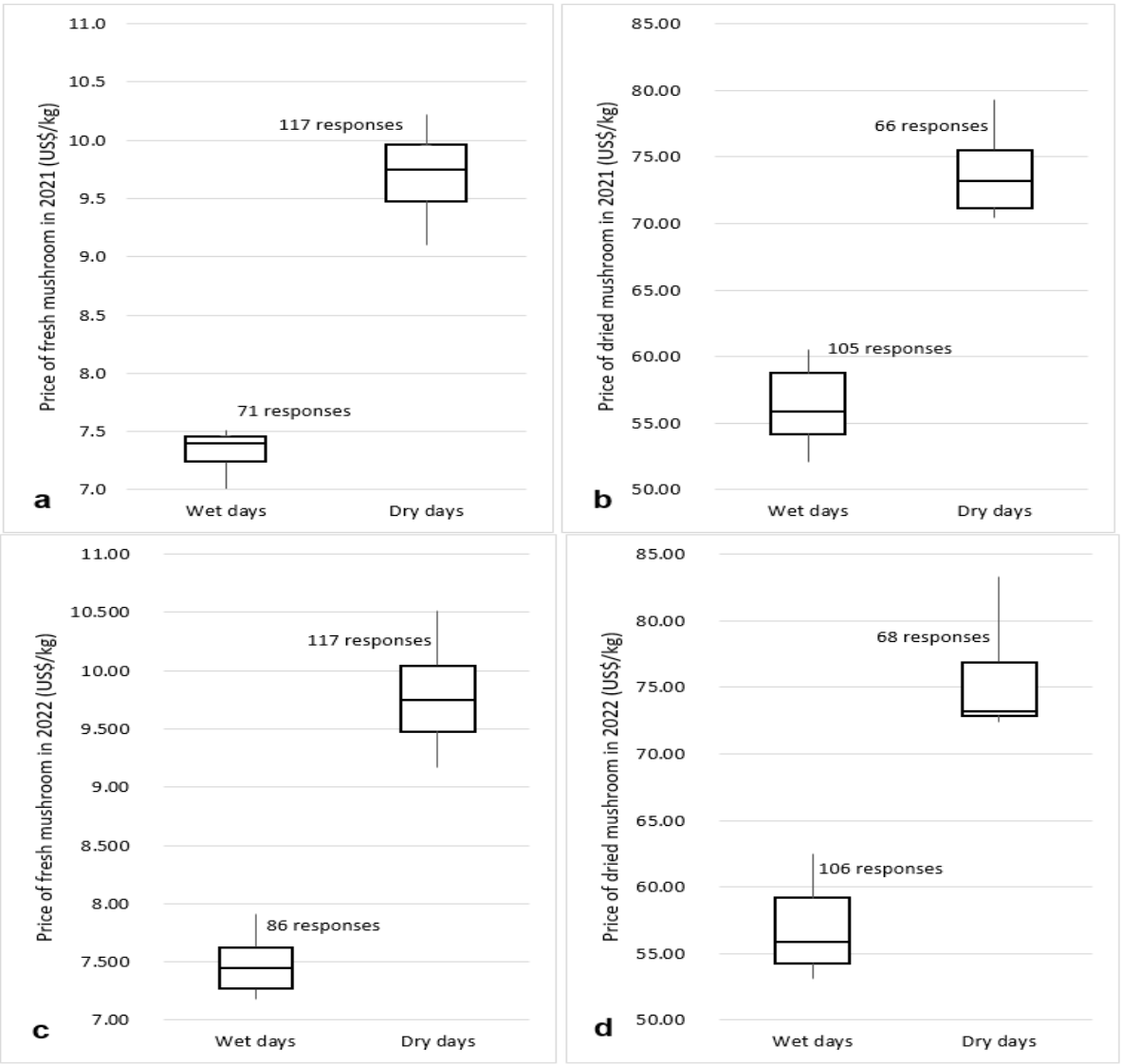

Figure 5. Box plots showing the price of fresh and dried *Russula griseocarnosa* mushrooms on dry and wet days over two years: **a**, **c**. Fresh mushrooms; **b**, **d**. Dried mushrooms; **a**, **b**. 2021; **c**, **d**. 2022.

The price of fresh mushrooms is lower than for edible *Russula* in local markets in Thailand, which can fetch 11-58 US$/kg (Sanmee et al., 2003; Srikram & Supapvanich, 2016). However, the price of *Russula griseocarnosa* is about 15-20% more expensive than edible *Russula* mushrooms collected in central and southern Vietnam (Chi, 2022). A key finding of our study was that mushroom prices were significantly depressed when collected on rainy days. This may be because mushrooms grow very quickly on wet days (Kiet, 2012) and contain more water, making drying more difficult. Mushrooms with high moisture contents are easier to crush and are more prone to decay (Chi, 2022). Overall, drying mushrooms collected on wet days results in a lower and less valuable grade of dried mushrooms.

Globally, there are about 970 species of edible mycorrhizal fungi, and many are a source of NTFPs, providing a portion of the livelihoods for low-income families in many parts of the world (Pérez - Moreno et al., 2021). In addition to local consumption, wild mushrooms are an important component of the international mushroom trade (He et al., 2014; Royse, Baars, & Tan, 2017). Many indigenous cultures have developed traditional knowledge of mycorrhizal fungi over many generations, and this knowledge supports food supplies and contributes to food security (Pérez - Moreno et al., 2021; Power, Salazar-García, Straus, Morales, & Henry, 2015).

3.5. Policy Setting and Management

Six government officials provided written replies (100% response), and the main findings from the survey questions are summarized in Table 4. Over the past decade, the Vietnamese government and local authorities in Bac Giang, Cao Bang, Lang Son and Quang Ninh provinces have encouraged local people to protect forests for the sustainable exploitation of NTFPs, including *Russula griseocarnosa* (Quang Ninh, 2020; Vietnam, 2021). Governments of these northeastern provinces of Vietnam have issued preferential policies to strengthen forest protection to maintain favorable forest conditions for mushroom growth, and also to encourage good harvesting practices (Decision No. 4618 and Decision No. 1038, Table 4). The government has trained some extension workers to provide technical support for harvesting and processing. Furthermore, since *Russula griseocarnosa* is widespread and abundant in Quang Ninh province, the provincial government has supported a small number of research projects to conserve and cultivate this edible species (Quang Ninh, 2020) (Table 4).

Table 4. Main findings from survey questions regarding policies for *Russula griseocarnosa* in Vietnam.

Question topic	Finding
Non-timber forest product development policy[1, 2]	✓ To encourage the development of non-timber forest products in association with forest protection ✓ Provide some financial support for sound non-timber product development programs ✓ Provide technical training on cultivation and sustainable exploitation of non-timber forest products
Policy for assisted natural regeneration of *Russula griseocarnosa* in the forest[1]	✓ To strictly protect forest areas where *Russula griseocarnosa* is distributed ✓ To establish community forest models to protect and promote natural regeneration ✓ Provide training in sustainable harvesting techniques, which requires leaving basal stipe mycelium and approximately 10% of the mushroom population in the forest at each harvest
Policies to support research on cultivation techniques[1]	✓ Set up research projects on cultivation techniques ✓ Encourage scientific research organizations to participate in research on cultivation techniques
Policies to support processing of *Russula griseocarnosa*[2]	✓ Promote local knowledge on mushroom processing ✓ Set up research projects on processing techniques ✓ Encourage scientific research organizations to participate in research on processing techniques
Policy to develop *Russula griseocarnosa* into specialty goods[2]	✓ Accelerate the identification of the geographical indication for *Russula griseocarnosa* ✓ Establish a *Russula griseocarnosa* brand with high quality
Policy for export[2]	✓ Improve the quality of dried mushrooms, ensure export standards ✓ Trade promotion to increase exports

Note: [1] Decision no. 4618/QD-UBND dated December 15, 2020 of the People's Committee of Quang Ninh province approving the framework project for conservation of genetic resources in Quang Ninh province in the 2021-2025 period.
[2] Decision no. 1038/QD-UBND dated April 22, 2022 of the people's committee of Quang Ninh province approving the project to develop chain of major agricultural products at provincial level period 2022 - 2025, orientation toward 2030.

Financial hardship remains a serious challenge in many rural areas in Asia. Similar to many other developing countries, Vietnam has implemented programs to alleviate rural poverty. Of relevance to this study are strategies for the socio-economic development of ethnic minority communities (Hoang-Duc et al., 2024). Therefore, the local *Russula griseocarnosa* business has already benefited from the promulgation of policies. These include improved protection of forest areas where the mushroom occurs, establishment of community forests, and training in sustainable harvesting techniques. At present, there are no robust forest science or socio-economic studies for *Russula griseocarnosa* in any policy documents. A broader understanding of the contribution of forest land in household economies is urgently

needed (Gautam & Andersen, 2016; Trædal & Vedeld, 2018). The push to further commercialize the trade in *Russula griseocarnosa* by establishing high-quality product brands is risky unless harvesting can be shown to be sustainable. However, so far *Russula* only fruits in wild habitats or in monoculture plantations of compatible host trees (Buyck, 2008).

It is well recognized that the sustainable management of NTFPs helps to maintain forest areas and provide stable livelihoods for communities dependent on mycorrhizal fungi and other NTFPs (Asamoah et al., 2024; Power et al., 2015; Wang et al., 2022). However, this field is in its infancy for the region where *Russula griseocarnosa* is being harvested, and this contrasts with central Vietnam, where participation of NTFPs in the value chain has been well documented (Nguyen, Lv, & Ngo, 2021; Nguyen, Lv, Vu, & Zhang, 2020). It is evident that more detailed studies on forest ecology and the use of forests by local people are urgently needed in northern Vietnam. Boa (2004) stated that the sustainable management of wild edible fungi must consider the forests as well as the forest users. Mushroom collectors and traders should be included in future planning processes when developing management guidelines for minimizing the impacts of harvesting *Russula griseocarnosa* and expanding the commercial trade. The model developed for matsutake, where mushroom harvesters are contributing their knowledge to formulate innovative management strategies (Brown, McLellan, Li, & Karunarathna, 2018), is worth considering. Vietnam's forestry development strategy has prioritized the development of NTFPs, including edible ectomycorrhizal mushrooms, to improve farmers' livelihoods (Vietnam, 2021). In addition to investing in research activities, the program encourages rural communities to participate in forest management and protection. Recently, Vietnam signed a new interim Forest Stewardship Standard for NTFPs (FSC, 2023). This may provide an opportunity to add value to the dried *Russula griseocarnosa* export trade in the future.

Communities living near forests are the people who have the most impact on those ecosystems (Dao & Hölscher, 2018; FSC, 2023). Therefore, NTFP development policies in Vietnam often target relevant communities. The findings in this study will be very useful for local governments, as these organizations are interested in finding effective solutions to improve the livelihoods of people living near forests. More broadly, the findings will be of interest to those engaged in forest conservation and use of forests by ethnic minority people across Asia. Priority research topics that arise from this study include documenting all the values of forests to the household economies of the different ethnic groups, establishing long-term plots to explore harvesting intensity pressures on mushroom yields and forest ecology, and establishing host tree plots with local people on non-forest village land to determine whether the mushroom can be cultivated.

4. CONCLUSIONS

Russula griseocarnosa is widely collected by rural people in northeast Vietnam, where the lower-quality fresh mushrooms are cooked and consumed by families and the higher-quality mushrooms are dried for local and export markets. Northeast Vietnam has 20 ethnic groups (Thao, 2017), and this study showed that communities from 8 groups participate in collecting *Russula griseocarnosa* and 4 ethnicities are engaged in trading. The majority of collectors (85%) and traders (57%) are women. We discovered that harvesting is concentrated in two peak fruiting periods at the start and end of the wet season; and that rainfall affects mushroom quality and price of the dried product. Despite a lack of scientific data, a number of policies have been created to promote further trade in this species with the view to improving rural livelihoods in a relatively poor part of Vietnam. Although several policies refer to the sustainable harvesting of NWFPs and improving the livelihoods of poor rural people, there remains a need to fully document the household economies in the region and their overall reliance on forest assets. Our study provides the first detailed account of the role of edible wild mushrooms in the rural setting of northeast Vietnam, and the data can now be used by local government officials when they implement policies in the field. It can also assist researchers planning to investigate other NTFPs, forest response to harvesting, and livelihood strategies of local ethnic groups, which will complement our findings.

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