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The ecology and saponins of Vietnamese ginseng – *Panax vietnamensis* var. *fuscidiscus* in North Vietnam

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Abstract

Species of the genus *Panax* L. known as ginsengs are perennial forest herbs. The medical values of ginsengs are well known. *Panax vietnamensis* var. *fuscidiscus* was found in Laichau province, North Vietnam in 2003 and is known as Laichau ginseng. Understanding the ecology and saponin of high economically valuable Laichau ginseng is becoming important for sustainable development and management. Plots of 400 m^2 (20 m × 20 m) were established to survey for Laichau ginseng's ecological characteristics. In addition, its root samples from natural forests and garden of local people were collected for saponin analysis and anatomy. The results indicated that Laichau ginseng naturally distributes in evergreen broadleaved forests in elevation zones up to 2,100 m above sea level. It can grow in both old-growth forests and anthropogenic-disturbed forests. However, the total crown area of tree (stem with a diameter at breast height ≥5 cm) layer must be high, ranging from 3.2 to 8.6 times of the land area. In addition, the cover of herb layer is also important, which must be ≥44% land area. The saponin content of Laichau ginseng in natural forest (23.85%) is statistically significantly higher than that of other ginsengs (3÷22.29%) naturally distributing in Vietnam. While saponin content of Laichau ginseng (18.48%) grown in the garden of local people is statistically significantly lower than that collected from natural forests. It is concluded that Laichau ginseng could be a potentially perennial forest herb for poverty reduction. However, growing this herb may be restricted to very narrow areas in high elevational evergreen broadleaved forests with a high cover rate of both tree and herb layers.

Keywords: Laichau, *Panax* L., Saponin, Sustainable management, Vietnamese ginseng

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Introduction

The genus *Panax* L. (Araliaceae) known as ginsengs consists of 19 species and subspecies worldwide, out of which two species grow in eastern North America and the other in eastern Asia (Pandey and Ali, 2012). Ginsengs are perennial forest herbs, which have been widely used as traditional medicines (Shim et al., 1987; Kochkin et al., 2013). The ginsenosides (triterpene glycosides) discovered more than 50 years ago are the main biologically-active compounds of *Panax* L. Of which, the dammarane-type ginsenosides are characteristic of *Panax* L. Until recently, more than 150 different ginsenosides of the dammarane series have been isolated from different *Panax* L. species (Qi et al., 2011; Yoshizaki et al., 2012). These indicate the importance of *Panax* L. as medicinal forest herbs.

In 1973, a ginseng species (Dung and Grushvisky, 1985) was found in central Vietnam and named as *P. vietnamensis* Ha et Grushv. - Vietnamese ginseng. This is the most southern distribution of *Panax* L. genus. In 2003, a subspecies of Vietnamese ginseng was described and named as *P. vietnamensis* var *fuscidiscus* K. Komatsu, S. Zhu & S.Q. Cai. This subspecies was found to be naturally distributing in the southern part of Yunnan Province, China and Laichau Province, North Vietnam (Zhu et al., 2003; Phan et al., 2013). In Vietnam, it is known as Laichau ginseng. There have been three ginseng species (*P. vietnamensis* Ha et Grushv, *P. stipulealatus* Tsai & K.m. Feng, and *P. bipinnatifidus* Seem.) and two subspecies (*P. vietnamensis* var *fuscidiscus* and *P. vietnamensis* var. *langbianensis*) found in Vietnam. Laichau ginseng has been traditionally used by local people for health improvement, and fever and stomachache treatments.

Laichau ginseng was reported to have restricted distribution in Muong Te and Sin Ho districts of Laichau province, Vietnam (Phan et al., 2013). However, recently we found a natural distribution of Laichau ginseng in other districts (Fig. 1) of Laichau province (Tuyen et al., 2019). Therefore, the objectives of this work were (1) to obtain information on the ecology of *P. vietnamensis* var *fuscidiscus* (Lai Chau ginseng) in Laichau and (2) to understand saponin content of Laichau ginseng compared to other ginsengs that could be used to develop and manage this economically valuable perennial forest herb sustainably.

Material and Methods

Field survey and importance value calculation

The previous report indicated that Laichau ginseng distributes naturally in a closed evergreen broadleaved forest on the elevation zones of >1,400 m above sea level (Phan et al., 2013). Therefore, the districts of Laichau province having natural forests with such conditions are targeted survey areas (Fig. 1). Firstly, identifying potential survey areas by using topographical and forest cover maps. Secondly, discussing with the staff of Forest Protection Department of Laichau province for further information on Laichau ginseng. Thirdly, meeting responsible persons in the district level for their guidance to communes/villages. Fourthly, interviewing local villagers for information on natural distributions of Laichau ginseng. Fifthly, conducting a field survey.

In the field, the first found herb of Laichau ginseng was used as the center of a survey plot (Fig. 1). A main plot of 400 m^2 (20 m × 20 m) was established for forest structure and species composition investigation. In the plot, all tree stems with a diameter at breast height (DBH) ≥5 cm were identified to species and measured for DBH, total height (H), and crown diameter (D_c). In the main plot, five subplots of 4 m^2 each (2 m × 2 m) were established in four corners and in the middle for shrub, bush, and seedling surveys. All stems were identified to species and classified to one of three height classes as ≤0.5 m, 0.5–1 m, and ≥1 m. In addition, herb and other lower vegetation in these five subplots were also investigated as its coverage (%), number of clumps, and height.

Overstory influences on herb communities in mature forests are well recognized through canopy cover (Past and Spies 1997; McKenzie et al. 2000). Therefore, the crown area of each species in the canopy layer is an important index governing herb communities. Species composition of the tree layer in each plot was calculated basing on Importance Value (*IV*). *IV* of each tree species was estimated following Eq. 1:

$$IV_i = \frac{ca_i}{CA} + \frac{n_i}{N} \quad (1),$$

in which IV_i is Importance Value of species *i*, ca_i is a total crown area of species *i* in a plot, n_i is a number of stems of species *i* in a plot. *CA* is a total crown area of all species in a plot and N is total stems of all species in a plot. *IV* of each species is >0 and ≤2. *IV* equals 2 if there is only one species in a plot.

Root sample collection

There were two types of roots collected. Five root samples were collected from Laichau ginseng which grew naturally in natural forests. One root sample was collected from Laichau ginseng which was grown in the garden of local people and these roots were two years old. All root samples were collected by ourselves. For saponin comparison among ginsengs naturally distributing in Vietnam, a root sample of *P. vietnamensis* was collected from its natural distribution in central Vietnam and another root sample of *P. stipulealatus* was collected from the garden of local people in Laichau Province. Totally, eight root samples were collected and analyzed for saponin. Each sample was analyzed for total saponin in triplicates.

Root anatomy and saponin analysis

Microscopic authentication refers to using microscopic technology to identify the characteristics of tissues, cells, and ergastic substances. It is an effective method to identify herbal medicine and prescriptions as it is fast, reliability, convenience, and low cost. Microscopic authentication is particularly useful for identifying herbs that have been physically processed (Liu et al., 2010). Root was sliced, the slice was then cleared by chloramine 10% and colored with green methylene and red alum, before observed. In addition, the root was ground, then adding solvent to root powder for observing.

Total saponin in ginseng roots was estimated by weighing as following the guidance of Vietnam Pharmacopoeia Dictionary and published reference (Gafner et al., 2004). Five grams powder of the dried root sample were accurately weighed then 100 ml *n*-hexan was added. The mixture was extracted in a Soxhlet extraction apparatus in six hours and filtered. The residue was continuously extracted by Soxhlet extraction apparatus with 100 ml of 70% methanol for 6 hours. The combined filtrate was concentrated under reduced pressure with a rotary evaporator to obtain the extract. The methanol extract was diluted in 30 ml of water and then fractionated with water saturated *n*-butanol until no color was observed in an n-butanol layer. The filtrated butanol extract was then evaporated under reduced pressure to yield butanol extract. This extract was dissolved into 10 ml of 70% ethanol then transferred into a porcelain beaker and evaporated the solvent to get the extract. The obtained extract was dried in an oven at 105 ^oC until constant weight. Total saponin content (X) was calculated as $X = [(b \times 100)/(m \times (100 - d))] \times 100$, where b is obtained saponin weight (g), d is moisture of root powder (%), and m is the initial weight of root powder (g).

Data analysis

The comparison of vegetation characteristics (total height/H, diameter at breast height/DBH, and crown diameter/D_c) in each layer (*e.g.* tree layer, herb layer) between two districts (Phong Tho and Tam Duong) and between two elevational zones (1,500–1,800 m and 1,800–2,100 m), and the comparison of total saponin content between species and between natural and planting conditions for Laichau ginseng was conducted by *t*-test at $p = 0.05$. The test uses one-tailed distribution and pair comparison. SAS 9.2 was employed for statistical analysis.

Results

Ecology

In Phong Tho and Tam Duong districts of Laichau province, Laichau ginseng is found to have natural distribution in elevation of 1,500–2,100 m above sea level (Table 1). The characteristics of forest tree layer vary considerably in each district and between two districts. In Phong Tho District, a number of species found in 400 m^2 plot vary between eight and 15 and number of stems are in between 19 and 39. Crown height is also much different, ranging from 8.9 m to 12.6 m tall. Forest canopy is different among elevations and it is generally including two or three layers. Total crown area ranges from 1,300 m^2/400 m^2 to 1,900 m^2/400 m^2 (Table 1). There were two plots with a canopy height of up to 20 m tall, leading to three crown layers. Of which, crown area ratio in 10–15 m was highest. While there were three plots with canopy height <15 m, leading to two crown layers. Of which, crown area ratio in 5–10 m layer was higher. In Tam Duong District, a number of species vary between five and 16, and a number of stems are more numerous than Phong Tho District, ranging from 31 to 52. Crown height is ranging from 10.5 m to 13 m tall, taller than that in Phong Tho District. Forest canopy is quite similar among elevations of three layers. Total crown area ranges from 1,900 m^2/400 m^2 to 3,500 m^2/400 m^2 (Table 1).

Table 1: Characteristics of the tree layer in 400 m^2 area

District	Plot	Elevation (m)	Number of species	Number of stems	H ±SE (m)	D_c± SE (m)	DBH±SE (cm)	Total crown area (m^2)	Ratio (%) of the crown area in different height class		
									5–10 m	10–15 m	15–20 m
PT	1	1,576	8	26	11.3±0.7	4.6±0.2	21.1±2.1	1,904	31	47	22
	2	1,626	8	25	10.2±0.2	4.6±0.2	14.7±0.6	1,793	52	48	
	3	1,728	11	39	8.9±0.1	3.2±0.1	13.6±0.4	1,299	95	5	
	4	1,808	11	19	12.6±0.6	5.3±0.4	25.5±2.1	1,832	18	62	20
	5	2,061	15	39	9.5±0.2	3.6±0.1	13.9±0.8	1,698	77	23	
Mean±SE			10.6±1.3	29.6±4.0	10.5±0.7	4.3±0.4	17.8±1.2	1,705.2[a]±106.9	54.6±14	37.0±10.2	8.4±5.2
TD	6	1,620	14	33	11.1±0.5	4.0±0.3	16.0±1.7	1,910	29	50	21
	7	1,827	14	52	11.3±0.5	4.2±0.3	15.8±1.2	3,452	13	38	49
	8	1,787	5	29	12.0±0.7	4.5±0.3	21.5±2.0	2,157	16	44	40
	9	2,048	12	31	10.5±0.4	4.1±0.3	16.2±1.9	2,038	33	56	11
	10	2,100	16	33	13.0±0.2	4.8±0.2	20.6±1.0	2,638	84	16	
Mean±SE			12.2±1.9	35.6±4.2	11.6±0.4	4.3±0.1	18.0±1.2	2,439.0[b]±281.6	35.0±12	40.8±6.9	24.2±9.2
Comparison between two elevation zones (Mean ±SE)											
1,500–1,800 m			9.2[c]±1.5	30.4±2.6	10.7±0.5	4.2±0.3	17.4±1.6	1,812.6±141.5	44.6±13.9	38.8±8.5	16.6±7.6
1,800–2,100 m			13.6[d]±0.9	34.8±5.4	11.4±0.6	4.4±0.3	18.4±2.1	2,331.6±323.0	45.0±14.9	39.0±9.0	16.0±9.1

H is stem height, D_c is crown diameter, and DBH is diameter at breast height. PT is Phong Tho District and TD is Tam Duong District. Different letters [a, b] indicate a significant difference of total crown area between two districts and letters [c, d] indicate significant difference of species number between two elevation zones at p =0.05

There were four plots with a canopy height of up to 20 m tall, leading to three crown layers. Of which, crown area ratio in 5–10 m layer was highest. While, there was only one plot with canopy height <15 m, leading to two crown layers. Of which, crown area ratio in 5–10 m layer was higher. Comparing characteristics of tree layer between two districts indicated that there was an only significant difference (p =0.05) in the total crown area (Table 1), indicating a higher crown area in Tam Duong District. While comparing between two elevation zones indicated an only significant difference (p =0.05) of species number (Table 1), indicating a higher number of species in 1,800–2,100 m elevation zone.

There are quite a high species number and stem density of shrub, bush, and seedling layer among study plots (Table 2); from 14 to 25 stems/20 m^2 belonging to 7–8 species in Phong Tho District and from 17 to 37 stems/20 m^2 belonging to 7–12 species in Tam Duong District. Stems distribute in all three height classes.

These indicate a high cover rate of shrub, bush, and seedling layer to shade lower layer. Comparing between two districts and between two elevational zones indicates no significant difference of shrub, bush, and seedling layer (Table 2).

The number of clumps of herbs, ferns, *etc.* is high in both districts; ranging from 15 to 33 in Phong Tho District and from 13 to 42 in Tam Duong District (Table 3), and species ranges from 7 to 11 in Phong Tho District and from 9 to 12 in Tam Duong District (Table 3). The most important indicator of herb and other lower vegetation layer is its coverage. It ranges considerably in each district and between two districts. In Phong Tho District, it ranges from 51 to 102%. While it is from 44 to 118% in Tam Duong District. The average height of herb and other lower vegetation layer in Phong Tho District is half of that in Tam Duong District (Table 3). Comparing between two districts indicates a significant difference (p = 0.05) of height (Table 3) as a taller one found in Tam Duong District. While there is no significant difference of herb and other lower vegetation layer between two elevational zones (Table 3).

Table 2: Characteristics of shrub, bush and seedling layer in 20 m^2 area

District	Plot	Stems in height class (m)			Number of stems	Number of species
		< 0.5 m	0.5 - 1.0 m	> 1 m		
PT	1	5	3	6	14	7
	2	5	3	6	14	7
	3	11	8	6	25	8
	4	8	6	6	20	8
	5	9	6	4	19	7
Mean±SE		7.6±1.2	5.2±1.0	5.6±0.4	18.4±2.1	7.4±0.2
TD	6	6	5	6	17	11
	7	8	2	19	29	7
	8	1	2	17	20	7
	9	4	6	11	21	7
	10	22	14	1	37	12
Mean±SE		8.2±3.6	5.8±2.2	10.8±3.4	24.8±3.6	8.8±1.1
Comparison between two elevation zones (Mean ±SE)						
1,500–1,800 m		5.6±1.6	4.2±1.1	8.2±2.2	18.0±2.1	8.0±0.8
1,800–2,100 m		10.2±3.1	6.8±2.0	8.2±3.2	25.2±3.4	8.2±1.0

PT is Phong Tho District and TD is Tam Duong District

Table 3: Characteristics of herb and other lower vegetation layer in 20 m^2 area

District	Plot	Number of species	Number of clumps	Coverage (%)	Height (m)
PT	1	7	25	56.6	0.67
	2	7	33	63.8	0.59
	3	11	25	94.2	0.91
	4	10	23	102.4	1.19
	5	10	15	51.0	0.77
Mean±SE		9.0±0.8	24.2±2.9	73.6±10.4	0.8^{a}±0.1
TD	6	12	40	118.2	1.21
	7	10	29	43.8	1.27
	8	9	25	69.2	1.43
	9	9	13	66.8	1.28
	10	10	42	106.2	1.49
Mean ±SE		10.0 ±0.5	29.8 ±5.3	80.8 ±13.7	1.3^{b} ±0.1
Comparison between two elevation zones (Mean ±SE)					
1,500–1,800 m		9.2±1.0	29.6±3.0	80.4±11.4	1.0±0.2
1,800–2,100 m		9.8±0.2	24.4±5.2	74.0±12.9	1.2±0.1

PT is Phong Tho District and TD is Tam Duong District. Different letters $^{a,\,b}$ indicate a significant difference of height between two districts at p =0.05

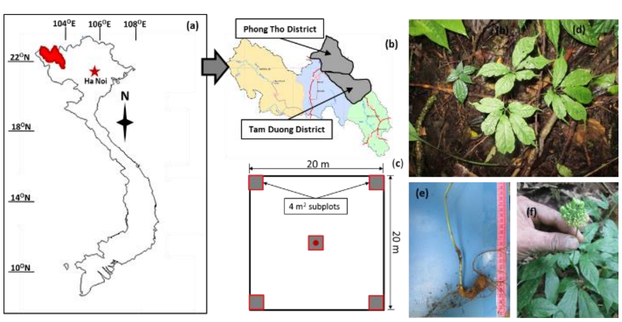

Fig. 1: Map of Vietnam (a), map of Laichau Province (b), the layout of survey plot (c), natural Laichau ginseng growing on thick and wet litter layer (d), root (e), and flower (f)

Root anatomy and saponin

A 16-year old root of Laichau ginseng collected from the natural forest was used. Observing a transverse section of the root through microscope indicated Laichau ginseng root contains mainly epidermis, cortex, phloem, xylem, and xylem rays (Fig. 2). While, results of root powder observation is indicated in Fig. 3, showing vessels, clusters of calcium oxalate, starch granules, and cock cells.

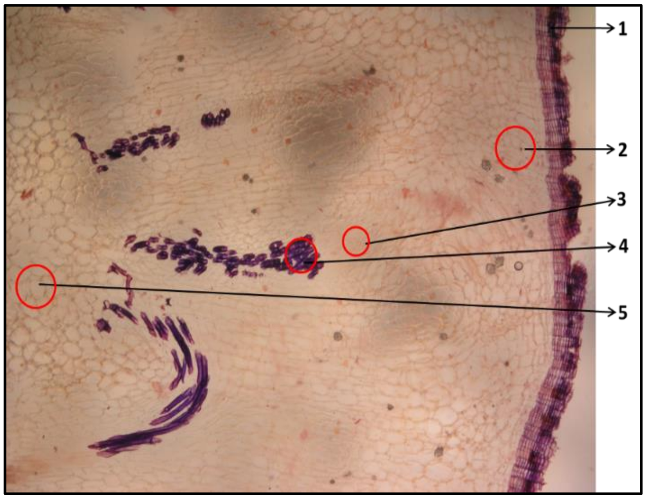

Fig. 2: Transverse section of Laichau ginseng root. 1. Epidermis; 2. Cortex; 3. Phloem; 4. Xylem; 5. Xylem rays

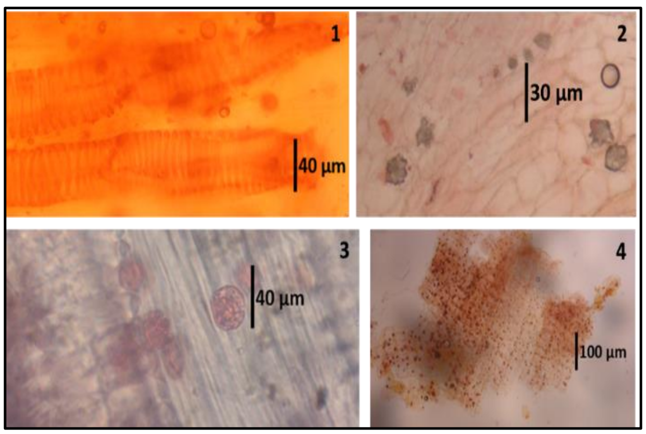

Fig. 3: Diagnostic features of Laichau ginseng root powder. 1. Vessels; 2. Clusters of calcium oxalate; 3. Starch granules; 4. Cock cells

There is a statistically significant difference in total saponin content among three ginsengs, which naturally distribute in Vietnam (Table 4). The highest saponin content belonged to Laichau ginseng (23.85%), reducing to *P. vietnamensis*. (22.29%), and to *P. stipulealatus* (3%). For Laichau ginseng, the roots collected from natural forests (23.85%) have statistically significant higher total saponin content than that of two-year old roots which were grown in the garden of local people (18.48%). The lowest saponin content (3%) belonged to *Panax stipulealatus* which was grown in the garden of local people in Laichau Province (Table 4).

Table 4: Total saponin content in different ginsengs naturally distributing in Vietnam

Species	Root source	Saponin (%) ±SE
Panax vietnamensis Ha et Grushv	Natural, central Vietnam	22.29 ±0.01[a]
Laichau ginseng - *Panax vietnamensis* var *fuscidiscus* K. Komatsu, S. Zhu & S.Q. Cai.	Natural, Laichau Province	23.85 ±0.62[b]
	Growing in the garden of local people in Laichau Province, two years old	18.48 ±0.08[c]
Panax stipulealatus Tsai & K.m. Feng	Growing in the garden of local people in Laichau Province, two years old	3.00 ±0.14[d]

Different letters [a, b, c, d] indicate significant difference of saponin contents between species at p =0.05

Discussion

Ecology

Ginsengs are perennial forest herbs (Anderson et al., 1993). It can only survive and grow well in under the shade of other vegetation as many other forest herbs (Past and Spies, 1997; McKenzie et al., 2000) and other shade-tolerant species (Thang et al., 2018). Therefore, forest structure including three layers as tree; shrub, bush and seedling; and herb and other lower vegetation (Turner et al., 1996) is an important indicator for the existence of ginseng. Low cover of tree layer (Tichy, 2016) will allow direct sunlight to forest floor and/or low cover of layers of shrub, bush and seedling; and herb and other lower vegetation will also allow direct sunlight to soil surface, reducing soil moisture, litter layers, soil organic carbon, *etc.*, which is not a favorable condition for existence of ginsengs (Beyfuss, 2000).

Comparing between two districts, it indicates that Laichau ginseng tends to naturally distribute in denser, numerous tree layer and higher crown area forests (Le and Nguyen, 2003) in Tam Duong District compared to Phong Tho District (Table 1).

Table 5: Composition of species in the tree layer

Plot	Formula of species composition
Phong Tho District	
1	0.693 *Litsea elongata* + 0.301 *Ilex loeseneri* + 0.25 *Tetradium glabrifolium* + 0.218 *Claoxylon indicum* + 0.206 *Mallotus apelta* + 0.179 *Meliosma arnottiana* + 0.088 *Quercus chrysocalyx* + 0.065 *Diospyros apiculata*
2	0.812 *Alnus nepalensis* + 0.423 *Alniphyllum eberhardtii* + 0.201 *Machilus chinensis* + 0.163 *Schima wallichii* + 0.121 *Magnolia conifera* + 0.103 *Mallotus apelta* + 0.093 *Helicia excelsa* + 0.084 *Alseodaphne andersonii*
3	0.349 *Eurya trichocarpa* + 0.264 *Alseodaphne andersonii* + 0.263 *Ficus fistulosa* + 0.255 *Symplocos adenopus* + 0.214 *Lindera balansae* + 0.144 *Meliosma arnottiana* + 0.111 *Alniphyllum eberhardtii* + 0.111 *Schima wallichii* + 0.106 *Machilus chinensis* + 0.094 *Ilex loeseneri*
4	0.542 *Ilex loeseneri* + 0.23 *Castanopsis chinensis* + 0.2 *Diospyros apiculata* + 0.185 *Cinnamomum curvifolium* + 0.154 *Symplocos adenopus* + 0.149 *Castanopsis fissa* + 0.149 *Cinnamomum rigidifolium* + 0.149 *Quercus chrysocalyx* + 0.096 *Lithocarpus fenestratus* + 0.074 *Elaeocarpus griffithii* + 0.074 *Syzygium hancei*
5	0.57 *Eurya trichocarpa* + 0.393 *Alseodaphne andersonii* + 0.229 *Schima wallichii* + 0.127 *Cinnamomum crispulum* + 0.097 *Alniphyllum eberhardtii* + 0.092 *Meliosma henryi* + 0.086 *Castanopsis fissa* + 0.074 *Schima noronhae* + 0.072 *Meliosma arnottiana* + 0.048 *Tetradium glabrifolium*
Tam Duong District	
6	0.336 *Lindera balansae* + 0.305 *Alseodaphne andersonii* + 0.27 *Rehderodendron macrocarpum* + 0.231 *Schima wallichii* + 0.154 *Alnus nepalensis* + 0.143 *Huodendron biaristatum* + 0.116 *Alniphyllum eberhardtii* + 0.107 *Meliosma arnottiana* + 0.071 *Tetradium glabrifolium* + 0.064 *Magnolia conifera*
7	0.619 *Styrax tonkinensis* + 0.302 *Lindera caudata* + 0.245 *Eurya acuminata* + 0.194 *Schefflera heptaphylla* + 0.135 *Alnus nepalensis* + 0.103 *Alniphyllum eberhardtii* + 0.093 *Lithocarpus bacgiangensis* + 0.07 *Lindera balansae* + 0.068 *Machilus chinensis* + 0.05 *Schima wallichii*
8	0.828 *Clethra petelotii* + 0.676 *Alniphyllum eberhardtii* + 0.397 *Schima wallichii* + 0.058 *Helicia excelsa* + 0.04 *Bridelia balansae*
9	0.785 *Rehderodendron macrocarpum* + 0.442 *Alniphyllum eberhardtii* + 0.278 *Schima wallichii* + 0.071 *Alseodaphne andersonii* + 0.071 *Ilex loeseneri* + 0.071 *Magnolia conifera* + 0.057 *Bridelia balansae* + 0.057 *Schima noronhae* + 0.051 *Symplocos adenopus* + 0.042 *Elaeocarpus griffithii*
10	0.226 *Lindera balansae* + 0.208 *Alseodaphne andersonii* + 0.2 *Alnus nepalensis* + 0.196 *Elaeocarpus griffithii* + 0.151 *Alniphyllum eberhardtii* + 0.13 *Schima wallichii* + 0.126 *Mallotus apelta* + 0.118 *Tetradium glabrifolium* + 0.111 *Altingia poilanei* + 0.099 *Huodendron biaristatum*

Only species with highest Importance Value (figure before scientific name) are shown

The most important characteristic of a forest, where Laichau ginseng distributes, is a crown area of the tree layer. It must be high, ranging from 3.2 to 8.6 times of land area, and no canopy gaps are found. Forest canopy must include more than two layers, which have higher shading capacity than simpler layer forest (Pabst and Spies, 1997; McKenxie et al., 2000; Dovciak and Halpern, 2010; Muscolo et al., 2014). Basing on a number of stems and crown area, the formula of species composition is generated (Table 5). It indicates the importance of each tree species in shading the land area and of tree species diversity on herb communities (Germany et al. 2017) and therefore indicating importance species in governing the existence of Laichau ginseng. Those should be considered when selecting lands for planting Laichau ginseng.

The height of shrub, bush and seedling layer is an important indicator for the natural distribution of Laichau ginseng. At the same coverage or total crown area of tree layer, the forest with shorter canopy is better in shading than the forest with taller canopy (Rijkers et al., 2000; Benitez et al., 2015). While diverse stem height forest will cover soil better than a simple one (Table 2). In addition, herb and other low vegetation layer indicate how forest soil is directly covered. The layer includes both annual and perennial plants, which are important to supply organic matter to the soil and maintain soil moisture; the importance for the existence of Laichau ginseng. Again, vegetation cover is an important ecological characteristic for the natural distribution of Laichau ginseng. It must include several layers to reduce direct sunlight penetrating to the forest floor, to supply organic matter, and to maintain soil moisture (Past and Spies, 1997; Beyfuss, 2000; McKenzie et al., 2000). Only that can promote the existence of Laichau ginseng.

Root anatomy and saponin

Root anatomy and features of root powder of Laichau ginseng are similar to that of other ginseng and plants (Liu et al., 2010; Tengku et al., 2013; Patil et al., 2016), which have been widely used as traditional medicines. The root powder shows a high ratio of clusters of calcium oxalate and starch granules, which are known as containing high saponin, the main active chemical component of ginseng.

The saponin content of Laichau ginseng is even higher than that of *P. vietnamensis* (Nguyen et al., 1994), which is well known for its traditional medicine and chemical value (Huong et al., 1997; Yamasaki, 2000; Kregiel et al., 2017). The higher saponin content of Laichau ginseng from natural forests compared to that grown in garden of local people may result from (1) age of roots from artificially grown ginseng was two years old compared to much older roots collected from natural forests, (2) under artificial condition, ginseng is carefully taken care of by local people because of its high economic value leading to fast growth, then capacity in accumulating saponin may be reduced. Therefore, to ensure the good quality of artificially grown ginseng, local people should not take care too much and they can grow it in natural forests for naturally growing. However, protecting planted ginseng in natural forests may become very hard work as its highly economical value leading to being stolen. Again, researches on planting Laichau ginseng should be conducted intensively to issue the applicable growing guideline, ensuring the quality/saponin content of planted ginseng compared to natural ones.

There is high variation (Standard error/SE = 0.62) of total saponin content among root samples of Laichau ginseng taken from natural forests (Table 4). This may indicate that saponin content is much affected by age of roots as collected roots may come from the high variation of root ages. Therefore, further studies on the saponin content of roots in different ages should be conducted to find out the best harvesting ages for Laichau ginseng. It is also valuable for suggesting local people, who have been growing ginseng, on root ages they can harvest for a higher benefit.

Conclusion

Laichau ginseng – *P. vietnamensis* var *fuscidiscus* naturally distributes in evergreen broadleaved forests of high canopy cover on the elevation zones of 1,500–2,100 m above sea level. The artificially grown Laichau ginseng has saponin content of 18.48%, lower than that from natural forests (23.85%). However, such figures are much higher than that of *P. stipulealatus*, which also naturally distributes in Laichau province. This indicates high medicine value of Laichau ginseng, which is a potential plant for poverty reduction in local communities.

Study on growing Laichau ginseng must be conducted. Since there is lower saponin content in roots grown in the garden compared to that from natural forest. It would be better to have experiments on both the garden and natural forest. Selecting vegetation types for growing Laichau ginseng is important, which must have high canopy cover to support growths of ginseng.

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Contribution of Authors

Tran VD: Conceived Idea, Data Analysis, Literature Review, Manuscript Writing
Pham QT: Designed Research Methodology, Data Collection, Data Interpretation
Tran TKH: Designed Research Methodology, Data Collection, Data Interpretation
Trinh NB: Designed Research Methodology, Data Collection, Data Interpretation
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