Structural characteristics, tree species diversity and distribution of medicinal plant species at Ta Kou nature reserve, Binh Thuan province

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ABSTRACT

This article aimed to investigate the forest structural characteristics, tree species diversity for plant communities of the tropical moist evergreen close forest and distribution of medicinal plant species at Ta Kou nature reserve, Binh Thuan province. In this research, the structural characteristics and tree species diversity were analyzed from data collected from 20 typical plots with the size of 0.1 hectares. The location of medicinal plant species is identified by GPS through the route survey method. Research results show that IVi% index of dominant and co-dominant tree groups accounting for 26.4%. The number of trees is most concentrated in class $D_{1.3} < 20$ cm and $H < 10$ m. The basal area and volume are mainly concentrated in class $D_{1.3} = 20 - 40$ cm and $H < 10$ m. In the study area, 47 species of 27 plant families were found, in which the Dipterocarpaceae family has the most species; 28 medicinal plant species belong to 24 families, one of which is typical for the study area named "Thay Thim" tree (*Olax obtuse* Blume) and some other species are rare and threatened with extinction in Vietnam such as *Streptocaulon juventas* (Lour.) Merr., *Eurycoma longifolia* Jack, *Stemona collinsae* Craib, *Drynaria bonii* H. Christ.

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1. Introduction

Vietnam is located in the Indo-Burma region, which is one of 25 global biodiversity hotspots (Myers et al., 2000). The biodiversity of Vietnam ranks 16th in the world (WB, 2005). In terms of biogeography, Vietnam is the intersection of flora and fauna systems of India - Burma, South China and Indonesia - Malaysia. The above characteristics have made Vietnam a biodiversity center of the world with various natural ecosystems, rich in endemic species and genetic resources.

However, under the increasing pressure of poverty, livelihoods, prioritizing the development of the market economy, especially timber and wildlife products, special-use forests are often under pressure from many different causes. According to research results of the Institute of Forest Inventory and Planning, the main reason why Vietnam's natural forests have been declining significantly in recent years is due to the conversion of forest land use purposes, over-exploitation, especially in the Southeast, Central Coast and Central Highlands (PNR, 2017). The quality of forests and biodiversity in the special-use forest system across the country have been warned to be seriously declining, the extinction risk of some species is very high, including medicinal plant species.

Ta Kou nature reserve in Binh Thuan province is a national nature reserve with rich and diverse flora and fauna systems. It is noted that Ta Kou mountain alone (694 m altitude and 1104 ha) has about 159 medicinal plant species, accounting for 23% of the total number of plant species in this mountain. However, the coastal sandy soil and dry climate that are typical for the region have made it difficult for agricultural production activities, causing the people’s high dependence on forest resources. As a result, biodiversity and natural resources continue to decline (BTDARD, 2012).

Thus, the study on forest structure characteristics, tree species diversity and the distribution of medicinal plant species in Ta Kou nature reserve are of great significance, helping foresters identify the forest status quo such as tree species composition, density, stratum structure, forest volume, distribution of medicinal plant species, identify medicinal plant species used as medicinal plants and determine the use of each species, etc. Thus, there are development orientations for forest protection, nurturing and restoration, biodiversity, medicinal plant sources and proposals for specific conservation measures for sustainable forest development.

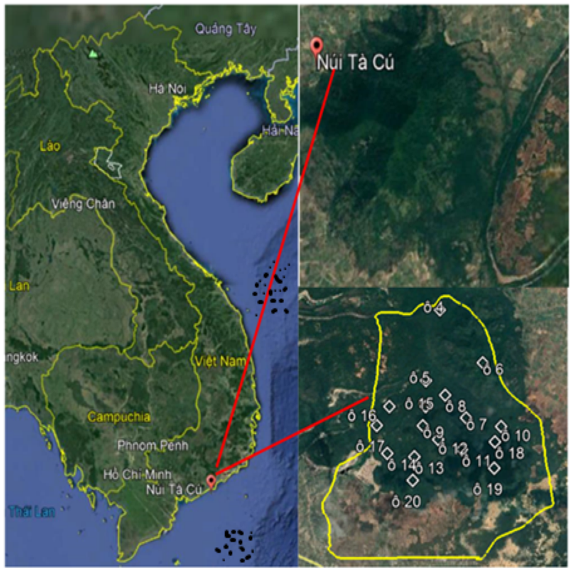

Figure 1. Location of sample plots in the study area.

2. Materials and Methods

2.1. Research subjects

The object of the study is the plant communities of the tropical moist evergreen close forest. The study forest’s status is medium forest (forest classification according to Circular No. 33/2018/TT – BNNPTNT of the Ministry of Agriculture and Rural Development) (MARD, 2018).

Research location: Ta Kou nature reserve, located in Ham Thuan Nam district, Binh Thuan province, with geographical coordinates: 10041’28” to 10053’01” North latitude; 107052’14” to 108001’34” East longitude (Figure 1).

The study period is from September 2019 to May 2021.

2.2. Research methods

2.2.1. Sampling methods

Data was collected from 20 typical sample plots with the size of 0.1 ha for the medium forest status in the study area. In each sample plot, trees with $D_{1.3} \geq 8$ cm were counted by species (S, species), diameter at breast height ($D_{1.3}$ cm) and tree height (H, m). The tree species composition was determined according to Pham (2003), Tran & Nguyen (2003) and Vo (2004). D1.3 was determined using a tape measure with an accuracy of 0.1 cm. H was determined using a Blume-Leiss hypsometer with an accuracy of 0.5 m. The survey method was using the traverse line going through the established standard plots to investigate the medicinal plant species. The location of the standard plots and the medicinal plant species were determined by global positioning system (GPS).

2.2.2. Data processing methods

The species composition structure was determined based on the important value index (IVi%) by formula (1) (Misra, 1968) through 3 criteria: (i) Relative density (Ni%) is the percentage ratio between the density of studied species of i and total density of all species; (ii) Relative basal area (Gi%) is the percentage ratio between the basal area of the studied species i and total basal area of all species; (iii) Relative frequency (Fi%) is the percentage ratio between the occurrence frequency of a studied species i and total frequency of occurrence of all species. Dominant and co-dominant species have IVi $\geq$ 5%. Identifying tree species composition (S, species), diameter ($D_{1.3}$ cm), height (H, m), basal area (G, m^2) and volume (M, m^3). The identified tree species diversity indexes include: Number of timber species and species richness index, evenness index and species diversity index. Of which, species richness was determined by the number of species (S) and Margalef's species richness index (d or dMargalef) (Margalef, 1968). The evenness index was determined based on Pielou index (J') (Pielou, 1975). Tree species diversity was determined based on the Shannon - Weiner diversity index (H') (Shannon & Wiener, 1963) and the Simpson dominance index (λ') (Simpson, 1949). The tree species diversity of the plant communities was determined based on the diversity index β - Whittaker (1972). The tree species diversity indexes were determined by formula (2) - (6); where S = total number of timber species encountered in all n sample plots; s = the average number of timber species encountered in a sample plot, $P_i = n_i/N$ (N is the total number of trees in the sample plot, and n_i is the number of trees of species i), Ln() = logarithm of base Neper.

$$\text{IVi} = (\text{Ni\%} + \text{Gi\%} + \text{Fi\%})/3 \qquad (1)$$

$$d_{\text{Margalef}} = (\text{S-1})/\text{Ln(N)} \qquad (2)$$

$$\text{J'} = \text{H'/H'max, with H'max} = \text{Ln(S)} \qquad (3)$$

$$\text{H'} = -\sum_{i=1}^{S} P_i * \text{Ln}(P_i) \qquad (4)$$

$$\lambda' = \sum (n_i * (n_i - 1)/(N * (N - 1)) \qquad (5)$$

$$\beta - \text{Whittaker} = \text{S/s} \qquad (6)$$

Research on medicinal plant species: the study referred to scientific documents of the authors Vo (2000), Do (2004) to accurately determine the scientific names, common names, morphological characteristics and uses of medicinal plants. Identification of medicinal plants on the list of rare and precious medicinal plants was based on the Vietnamese Red List of medicinal plants (2006), Decree No.06/2019/ND-CP dated January 22, 2019, of the Government and the Red Book of Vietnam (2007). The frequency of occurrence of medicinal plant species was calculated by the formula (7); where Ni is the number of trees of the species collected on the survey routes; N is the total number of trees collected on the survey routes. Mapinfo software was used to build a distribution map of medicinal plant species encountered in the study area.

$$\text{Fi} = (\text{Ni/N})*100 \qquad (7)$$

3. Results and Discussion

3.1. Plant family and tree species structure

3.1.1. Plant family structure

The results of analyzing 20 plant communities on 0.1-ha plots of the tropical moist evergreen close forest in the medium forest status in Ta Kou area, Binh Thuan Province showed that:

Forty-seven species of timber plants belonging to 27 plant families have been identified, of which the family with the most species is the Dipterocarpaceae family with 5 species. Next is the Anacardiaceae family with 4 species. Families such as Annonaceae family and Caesalpinioideae subfamily have 3 species, the remaining families have 1 to 2 species. Dipterocarpaceae family is the family with the largest number of individuals (333 individuals).

3.1.2. Tree species structure

In the study area, 47 species of trees were encountered (Table 1), of which *Shorea roxburghii* Roxb is the species with the highest IV% (7.00%), followed by these 3 species: *Careya sphaerica* Roxb, *Dillenia ovata* Wall, *Diospyros eriantha* Champ ex Benth. This is a dominant and co-dominant species group, which contributes an average of 26.4% in terms of N, G and F. In addition, 43 other species also contribute greatly to the species diversity and sustainable development of the forest. Species composition formula: 0.7Sr + 0.694Cs + 0.664Do + 0.582De + 7.36Os. Where: Sr stands for Shorea roxburghii Roxb, Cs for Careya sphaerica Roxb, Do for Dillenia ovata Wall, De for Diospyros eriantha Champ ex Benth, and Os for the other species.

3.2. Stand structure characteristics

3.2.1. Structure in terms of density, basal area and volume by diameter group

Density (N, trees/ha), basal area (G, m^2/ha) and volume (M, m^3/ha) in 4 diameter groups $D_{1.3}$ (< 20, 20 – 40, 40 - 60 and > 60 cm) are presented in Table 2.

Calculation results show that the average density is 1.067 trees/ha; in which the majority (60.3% or 643 trees/ha) is in the $D_{1.3} < 20$ cm, the lowest is in the $D_{1.3} > 60$ cm (0.2%

Table 2. Density, basal area and volume by diameter group in medium forest status

Group $D_{1.3}$ (cm)	N (number of trees)	G (m^2)	M (m^3)	Ratio (%) N	Ratio (%) G	Ratio (%) M	Ratio (%) Average
< 20	643	9.87	33.23	60.3	28.6	22.7	37.2
	159[1]	2.47	8.39	14.9	7.2	5.7	9.3
20 - 40	409	21.77	94.93	38.3	63.0	65.0	55.4
	148	8.35	37.34	13.9	24.2	25.6	21.2
40 - 60	13	2.31	14.02	1.2	6.7	9.6	5.8
	9	1.55	9.49	0.8	4.5	6.5	3.9
> 60	2	0.61	3.94	0.2	1.8	2.7	1.6
	1	0.24	1.45	0.1	0.7	1.0	0.6
Total	1.067	34,56	146.11	100.0	100.0	100.0	100.0
	317	12.61	56.67	29.7	36.5	38.8	35.0

Unit: 1 ha.
[1]The values in the bottom rows belong to dominant and co-dominant species or ecologically significant species groups.

Table 1. Species composition ratio (IV%) in high tree layer in medium forest status

No.	Species	N (number of trees)	G (m^2)	F (frequency)	Ratio (%) N%	Ratio (%) G%	Ratio (%) F%	Ratio (%) IVI%
1	*Shorea roxburghii* Roxb	80	3.62	85	7.50	10.47	3.03	7.00
2	*Careya sphaerica* Roxb	77	3.72	80	7.22	10.75	2.85	6.94
3	Dillenia ovata Wall	87	2.84	100	8.15	8.21	3.57	6.64
4	*Diospyros eriantha* Champ ex Benth	73	2.43	100	6.84	7.04	3.57	5.82
	Sum of 4 species	317	12.61	365	29.71	36.48	13.01	26.40
	Other species	750	21.95	2440	70.29	63.52	86.99	73.60
	Total	1.067	34.56	2805	100.0	100.0	100.0	100.0

Unit: 1 ha.

or 2 trees/ha). The basal area is 34.56 m^2/ha; in which the largest is in the group $D_{1.3}$ = 20 - 40 cm (63.0% or 21.77 m^2/ha), the smallest is in the group $D_{1.3}$ > 60 cm (1.8% or 0.61 m^2/ha). The total volume is 146.11 m^3/ha; in which the largest in is the group $D_{1.3}$ = 20 - 40 cm (65.0% or 94.93 m^3/ha), the smallest is in the group $D_{1.3}$ > 60 cm (2.7% or 3.94 m^3/ha). Dominant and co-dominant or ecologically significant species groups contribute N, G and M in all $D_{1.3}$ groups; in which the highest proportion is in the $D_{1.3}$ = 20 - 40 cm (21.2%) and the smallest percentage is in the $D_{1.3}$ > 60 cm (0.6%).

3.2.2. Structure in terms of density, basal area and volume by height class

Density (N, trees/ha), basal area (G, m^2/ha) and volume (M, m^3/ha) in three height classes (< 10, 10 - 15 và > 15 m) are presented in Table 3.

Calculation results show that the majority (84.1% or 897 trees/ha) is in the H class < 10 m, followed by class H = 10 - 15 m (15.6% or 166 trees/ha), the remaining 0.3% (4 trees/ha) is in class H > 15 m. The basal area is mainly in the class H < 10 m (66.5% or 22.99 m^2/ha), the smallest is in class H > 15 m (1% or 0.35 m^2/ha). Total volume is 146.11 m^3/ha; in which, the largest is in class H < 10 m (55.8% or 81.54 m^3/ha), the smallest is in class H > 15 m (1.7% or 2.54 m^3/ha). Dominant and co-dominant or ecologically significant species groups contribute N, G and M in all H classes; in which the highest proportion is in class H < 10 m (20.7%), followed by class H = 10 - 15 m (13.4%) and the smallest is in class H > 15 m (0.9%).

3.3. Plant family diversity and tree species diversity in the tropical moist evergreen close forest

3.3.1. Plant family diversity in the medium forest status

The results of analyzing 20 plant communities on 0.1-ha sample plots of the tropical moist evergreen close forest are presented in Table 4.

The average number of families encountered in the 0.1-ha sample plot was 20 families; ranging from 16 to 25 families, coefficient of variation CV = 12.2%. The average number of timber species ranges from 1 to 5 species/family. The

Table 3. Density, basal area and volume by height class in medium forest status

H class (m)	N (number of trees)	G (m^2)	M (m^3)	Ratio (%) N	Ratio (%) G	Ratio (%) M	Ratio (%) Average
< 10	897	22.99	81.54	84.1	66.5	55.8	68.8
	250[1]	7.19	26.06	23.4	20.8	17.8	20.7
10 - 15	166	11.22	62.03	15.6	32.5	42.5	30.2
	65	5.11	28.36	6.1	14.8	19.4	13.4
> 15	4	0.35	2.54	0.3	1.0	1.7	1.0
	2	0.31	2.25	0.2	0.9	1.5	0.9
Total	1.067	34.56	146.11	100.0	100.0	100.0	100.0
	317	12.61	56.67	29.7	36.5	38.8	35.0

Unit: 1 ha.
[1]The values in the bottom rows belong to dominant and co-dominant species or ecologically significant species groups.

families with the largest number of species are Dipterocarpaceae (5 species) and Anacardiaceae (4 species). The average density is 107 trees/0.1 ha; in which the Dipterocarpaceae family has the highest average number of individuals (17 trees/0.1 ha or 15.9%). The average abundance (d) of the families is 4.09 ranging from 3.24 to 5.09 CV = 12.3%. The average evenness of the families is 0.91/0.1 ha; ranging from 0.85 to 0.96 CV = 3.5%. The average diversity index H' is 2.72 the lowest is 2.44 and the highest is 2.97 CV = 6.0%. The average Simpson dominance index is 0.07 the lowest is 0.05. and the highest is 0.12. The sampling plots receiving the Simpson dominance index is 40% larger than the average value compared to the total number of sampling plots. In general, the plant family diversity of the natural medium evergreen broad-leaved mountain timber forest in study is only above the average level.

Comparing this result with that of Phan Minh Xuan (2019)'s research, the average number of families encountered in the sample plot herein is similar to that in Binh Chau - Phuoc Buu (BCPB) area which is 20 families and the families with the largest number of species are mainly Dipterocarpaceae and Anacardiaceae. However, the variation in the number of families among plant communities in the BCPB area is larger than Ta Kou area ($CV_{BCPB} = 16.3\% > CV_{Ta\ Kou} = 12.2\%$). Diversity indices (d, J', H') in Ta Kou area are respectively higher than BCPB area (Tcalculating (d) = 5.34; Tcalculating (J') = 4.86; Tcalculating (H') = 4.23; $P < 0.05$), showing that the diversity of plant families in Ta Kou area is higher than BCPB area.

Table 4. Statistical characteristics of plant family diversity for medium forest status

No.	Descriptive statistics	F (number of families)	N (number of trees)	d	J'	H'	λ'
1	Number of sample plots	20	20	20	20	20	20
2	Average	20	107	4.09	0.91	2.72	0.07
3	Standard Error	0.55	2.59	0.11	0.01	0.04	0.00
4	Range	9	37	1.84	0.11	0.53	0.07
5	Minimum	16	88	3.24	0.85	2.44	0.05
6	Maximum	25	125	5.09	0.96	2.97	0.12
7	Coefficient of variation (CV%)	12.2	10.8	12.3	3.5	6.0	26.4

Unit: 0.1 ha.

3.3.2. Diversity of tree species in medium forest status

The total number of timber plant species encountered in 20 plant communities on 0.1-ha plots is 47 species. The average number of timber plant species encountered is 28 species/0.1 ha; ranging from 22 to 35 species; CV = 12.6%. The average number of individuals is 107 trees/0.1 ha; ranging from 88 to 125 trees; CV% = 10.8% (Table 5).

The average species abundance index (d) is 5.80; ranging from 4.59 to 7.15. The abundance of timber plant species is quite even (J' = 0.92), ranging from 0.88 to 0.95. The average Shannon diversity index (H') is 3.08; ranging from 2.82 to 3.26. The average Simpson dominance index λ'

Table 5. Statistical characteristics of tree species diversity for the medium forest status

No.	Descriptive statistics	S (number of species)	N (number of trees)	d	J'	H'	λ'	β
1	Number of sample plots	20	20	20	20	20	20	20
2	Average	28	107	5.80	0.92	3.08	0.05	1.70
3	Standard Error	0.79	2.59	0.16	0.004	0.03	0.002	0.05
4	Range	13	37	2.56	0.07	0.44	0.03	0.79
5	Minimum	22	88	4.59	0.88	2.82	0.04	1.34
6	Maximum	35	125	7.15	0.95	3.26	0.07	2.14
7	Coefficient of variation (CV%)	12.6	10.8	12.3	2.0	4.6	18.4	12.8

Unit: 0.1 ha.

is 0.05; ranging from 0.04 to 0.07. The average β – Whittaker diversity index is 1.70; ranging from 1.34 to 2.14; the diverse components have relatively low variation; in which the one with the strongest variation is the Simpson dominance index λ' (CV = 18.4%); followed by the β - Whittaker index (CV = 12.8%) and the number of species (CV = 12.6%). The Pielou's evenness index (J') has the lowest variation among plant communities (CV = 2.0%).

A comparison between this result and that in the research of Nguyen (2018) and Phan (2019) shows common characteristics in all 3 study areas (Ta Kou, BCPB and Nui Ong): tree species are not evenly distributed on the standard plots, there is no statistically significant difference in the average number of tree species encountered in the sample plots (0.1 – 0.2 ha) with a range from 23 species (Nui Ong) to 29 species (BCPB) compared to 28 species in Ta Kou ($P > 0.05$). Coefficient of variation in number of species in Ta Kou area (CV = 12.6%) is lower than BCPB area (CV = 22.7%) and Nui Ong area (CV = 22.4%). The comparison results show that: J'and H' indices in Ta Kou area are statistically significantly higher than in BCPB area, respectively ($T_{calculating\ (J')} = 4.02$; $T_{calculating\ (H')} = 2.66$; $P < 0.05$); however, there is no statistically significant difference in species abundance index ($T_{calculating\ (d)} = 0.89$; $P > 0.05$). Meanwhile, d, J', H' indices in Ta Kou area are statistically significantly higher than in Nui Ong area, respectively ($T_{calculating\ (d)} = 3.43$; Tcalculating (J') = 2.99; $T_{calculating\ (H')} = 4.86$; $P < 0.05$). In general, the diversity of tree species in Ta Kou area is higher than in BCPB and Nui Ong areas. On the other hand, the diversity index β - Whittaker in the medium forest of Ta Kou (β = 1.70) is lower than that of Nui Ong (β = 1.78) and BCPB (β = 3.76). This proves that the tree species composition in Ta Kou area is more even than the other two areas. In other words, the environmental conditions under the medium forest canopy in the study area (Ta Kou) are more stable than the medium forest conditions in BCPB and Nui Ong areas.

3.4. Diversity of tree species by stand structure

The diversity of tree species based on four diameter groups $D_{1.3}$ (< 20, 20 – 40, 40 - 60 and > 60 cm) and three height classes H (< 10, 10 - 15 and > 15 m) of the medium forest in the study area are presented in Table 6.

The analysis results show that the two factors S (number of species) and N (stand density) decrease gradually, following the increase of group $D_{1.3}$ and H class. The decrease of S and N leads to a decrease in the H' index and an increase in the λ' index. β – Whittaker index in the $D_{1.3}$ groups and H classes is the ratio between the total number of tree species encountered in 20 plant communities and the number of tree species encountered in each group D1.3 and class H. β – Whittaker index's value is 1 in group $D_{1.3} < 20$ cm and $D_{1.3} = 20 - 40$ cm; and class H < 10 m, indicating that most of the tree species are present in group $D_{1.3} < 20$ cm; $D_{1.3} = 20 - 40$ cm and class H < 10 m. In contrast, β - Whittaker index receives a high value in group $D_{1.3} > 60$ cm and class H > 15 m, indicating that only a very small number of tree species reaches the largest size in the forest stand.

3.5. Distribution of medicinal plant species in the study area

3.5.1. List of medicinal plant species on 3 survey routes in the study area

The survey results on 3 routes showed that all 538 individuals used for medicinal purpose were recorded with different uses, belonging to 28 species and 24 families (Table 7). The families with the highest number of species are Fabaceae with 3 species accounting for 10.71%, Smilacaceae and Asteraceae with 2 species (accounting for 7.14%), the remaining 21 families has 1 species (accounting for 75%) (Figure 2).

Among the 28 species belonging to 24 investigated families, there is one typical species for the study area, which is "Thay Thim" tree belonging to the Olacaceae family. In addition, there are some species on the Red List of Vietnamese medicinal plants (2006) which are rare and threatened with extinction in Vietnam such as: *Streptocaulon juventas* (Lour.) Merr., *Eurycoma longifolia* Jack, *Stemona collinsae* Craib, *Drynaria bonii* H. Christ.) (Nguyen, 2016). The difference in occurrence frequency between the highest frequency species and the smallest frequency species is 15.1%.

Table 6. Diversity of tree species by diameter group and height class in medium–forest status

Structure	Group/class	S (number of species)	N (number of trees)	d	J'	H'	λ'	β
Diameter $D_{1.3}$ (cm)	< 20	47	643	6.43	0.94	3.61	0.03	1.00
	20 - 40	47	409	6.86	0.88	3.38	0.05	1.00
	40 - 60	10	13	2.76	0.90	2.06	0.12	4.70
	> 60	2	2	0.91	0.92	0.64	0.33	23.50
Height (m)	< 10	47	897	6.14	0.93	3.58	0.03	1.00
	10 - 15	46	166	7.76	0.86	3.28	0.05	1.02
	> 15	4	4	1.54	0.98	1.35	0.14	11.75

Table 7. List of medicinal plant species on 3 survey routes in the study area

No.	Scientific species	Scientific family
1	*Stemona collinsae* Craib.	Stemonaceae
2	*Abrus precatorius* L.	Fabaceae
3	*Tetracera indica* (L.) Merr	Dilleniaceae
4	*Gnetum montanum* Markgr	Gnetaceae
5	*Cyclea barbata* Miers	Menisperimaceae
6	*Pandanus odoratissimus* L.f.	Pandanaceae
7	*Mucuna pruriens* (L.) DC.	Fabaceae
8	*Caryota mitis* Lour.	Arecaceae
9	*Adiantum caudatum* L.	Adiantaceae
10	*Uraria crinita* (L.) Desv. ex DC.	Fabaceae
11	*Streptocaulon juventas* (Lour.) Merr.	Asclepiadaceae
12	*Smilax cambodiana* Gagnep.	Smilacaceae
13	*Smilax ovalifolia* Roxb.	Smilacaceae
14	*Dioscorea persimilis* Prain et Burk	Dioscoreaceae
15	*Passiflora foetida* L.	Passifloraceae
16	*Strychnos nux-vomica* L.	Loganiaceae
17	*Eurycoma longifolia* Jack	Simaroubaceae
18	*Phyllanthus emblica* L.	Euphorbiaceae
19	*Costus speciosus* Sm.	Costaceae
20	*Melastoma candidum* D. Don	Melastomaceae
21	*Nepenthes mirabilis* (Lour.) Druce	Nepenthaceae
22	*Eupatorium odoratum* L.	Asteraceae
23	*Emilia sonchifolia* DC.	Asteraceae
24	*Alpinia conchigera* Griff.	Zingiberaceae
25	*Polia arenaria* Lour.	Caryophyllaceae
26	*Rhodomyrtus tomentosa* (Ait.) Hask	Myrtaceae
27	*Drynaria bonii* H. Christ.	Polypodiaceae
28	*Olax obtuse* Blume	Olacaceae

3.5.2. Application of Google Earth in the management of medicinal plant species

From the information collection (coordinates, species name identification, morphological characteristics, uses, images...) of medicinal plant species discovered on 3 survey routes. Using Google Earth software, species description and their representation on the map application (Figure 3) can facilitate the monitoring and management of medicinal plant species. In particular, at the coordinates of a medicinal plant species there will be a set of information about its attributes to be noticed such as: species name, scientific name, scientific family, coordinates, morphology, uses (Figure 4)... This will help forest management agencies better manage the database collected from the field without having to go through notebooks or Microsoft editing software such as Word, Excel.

The survey results showed that, on the 3 survey routes, the medicinal plant species appeared around the study area are quite rich and diverse. This is very important information to help authorities and forest owners manage, monitor and check the medicinal plant species distribution status, locations of medicinal genetic resources with high scientific and application value, serving the development, replication and conservation purposes.

4. Conclusions

The study has identified 47 timber plant species belonging to 27 plant families, in which there are 4 dominant and co-dominant tree species accounting for 26.4%, including *Shorea roxburghii* Roxb, *Careya sphaerica* Roxb, *Dillenia ovata* Wall, *Diospyros eriantha* Champ ex Benth. The highest number of trees is in the group $D_{1.3} < 20$ cm and class $H < 10$ m, the smallest number is in group $D_{1.3} > 60$ cm and

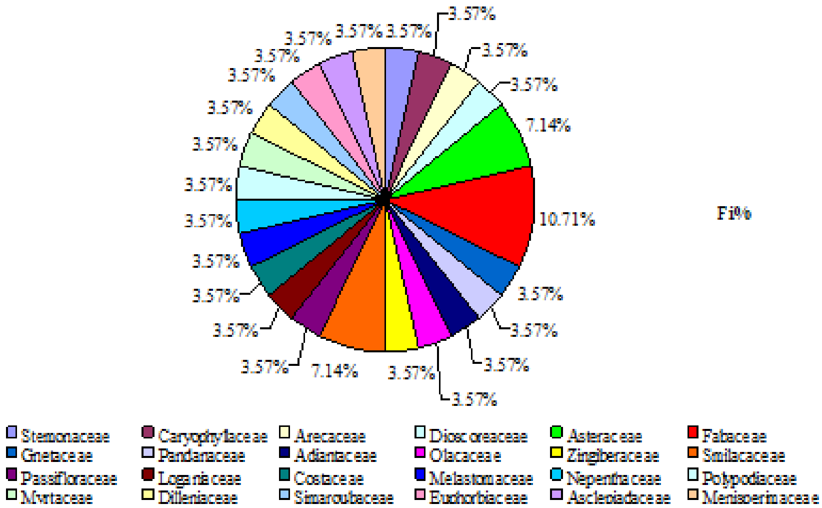

Figure 2. The species's frequency of occurrence on 3 survey routes.

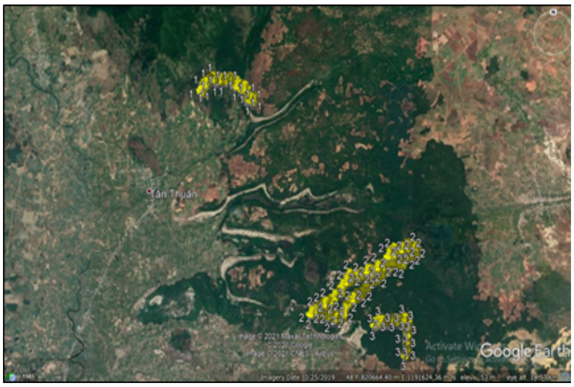

Figure 3. Coordinates of medicinal plant species in the study area.

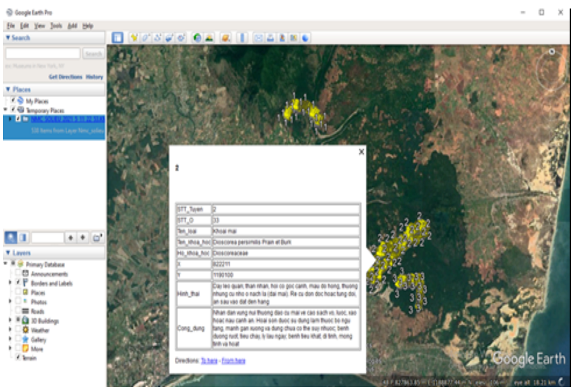

Figure 4. Managing medicinal plant species on Google Earth application.

class H > 15 m. The largest cross-section and timber volume are mainly in group $D_{1.3}$ = 20 - 40 cm and class H < 10 m, the smallest numbers are in group $D_{1.3}$ > 60 cm and class H > 15 m.

Analysis on plant family diversity and tree species diversity based on basic biodiversity indices such as Shannon – Weiner (H'), Pielou (J'), Margalef (d), Simpson (λ') indicated that the plant family diversity and tree species diversity in the study area is above average level.

The composition of medicinal plant species in the survey area is very rich, showing a great potential in medicinal species conservation and development. The use of Google Earth software helps the search, monitoring and management of medicinal plant species quick, convenient, and scientific.

Conflict of interest

The authors declare no conflict of interest.

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