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# Plant biodiversity, value, and distribution of Rubiaceae at Hon Ba Nature Reserve, Khanh Hoa province, Vietnam

Huong Manh Kieu [1], Quy Van Nguyen [1], Ha Thi Nguyen [1], Thach Ngoc Do [2] and Hop Van Nguyen [1,*]

[1] *Faculty of Natural Resource and Environment, Vietnam National University of Forestry – Dongnai Campus, DongNai, Vietnam.*
[2] *Technical Department, Hon Ba Nature Reserve, Khanh Hoa, Vietnam.*

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## Abstract

Rubiaceae is the most prominent plant family after Orchidaceae, Asteraceae, and Fabaceae. It is important for all vegetation, especially tropical rainforests. Moreover, they also have uses and conservation values: food, timber, medicinal, and species threatened to varying degrees. This article presents the study outcomes of the Rubiaceae family in Hon Ba Nature Reserve Khanh Hoa province, Vietnam. The methods of transect surveys and sample plots were utilized in this investigation to collect data. Of 94 species, 42 genera were recorded; Lisianthus was the most diverse genus. Twelve species were listed in Viet Nam Red Data Book (2007), Viet Nam Red List of Medicinal Plants (2019), and IUCN Red List (2021). The phytogeographical factor highest were endemic to Vietnam (38.30%), the Indochina-India (20.21%), and the Asian tropical element (12.77%); the remaining factor was deficient. The Spectrum of Biology (SB) of Rubiaceae family was summarized as follows: SB = 94.68Ph + 4.26Ch + 1.06Th. There were five use-value groups identified, and the medicinal plants were the highest number of species (25.53%), followed by timber (6.38%), edible plants (4.26%), dyes, and other groups was the lowest number of species (5.32%). The species plant distributed was from below 200 m to above 1400 m, the number of species highest at 200 m - 400 m, and the lowest above 1400 m. The medium forest was the most diverse species and genera; the lowest was a vibrant forest. These were important results underpinning strategies and solutions for sustainable conservation of this natural resource.

**Keywords:** Distribution; Diversity; Hon Ba Nature Reserve; Rubiaceae; Value; Vietnam

## 1. Introduction

With 13,183 species in 611 genera, the significance of Rubiaceae in terms of species number is confirmed, and its position as the fourth largest angiosperm family is confirmed after Orchidaceae, Asteraceae, and Leguminosae [1]. Rubiaceae family is easily identified by the existence of simple, opposite, or whorled, entire leaves, interpetiolar stipules, and an inferior ovary [2]. Most species are small trees or shrubs. Still, nearly all life-forms are found, including large trees, annual and perennial herbaceous plants, woody monocausal dwarfs, lianas, epiphytes, geofrutices (more or less herbaceous stems with a woody rootstock), myrmecophiles (hollow stems or unique chambered tubers, containing ants or ant colonies), and rarely succulent or aquatic life-forms [1, 3]. Rubiaceae has a cosmopolitan distribution, but species diversity and biomass are distinctly concentrated in the tropics and subtropics, especially in humid lowland forests. It is often the most species-abundant woody plant family [3]. The Rubiaceae is essential to all tropical vegetation, especially rainforests [4]. Taxons in the Rubiaceae family are a lot of economic value: food, timber, medicine, and the diversity of conservation value, as recorded in previous research papers.

* Corresponding author: Hop Van Nguyen
Faculty of Natural Resource and Environment, Vietnam National University of Forestry – Dongnai Campus, DongNai, Vietnam.

In Vietnam, the Rubiaceae is diverse and abundant, with 439 species in 83 genera [5]; another study recorded 93 genera and 450 species, widely distributed throughout the country [6]. Besides that, the studies about the diversity of Rubiaceae in Pu Huong Nature Reserve, Nghe An province; Lo Go-Xa Mat National Park, Tay Ninh province; Lam Dong province were described [7-10].

Hon Ba Nature Reserve in Khanh Hoa province is a hotspot for biodiversity, with the diversity of natural conditions and convergence of many plant species, including 752 species, 468 genera, 120 real families, and 43 species listed in the Vietnam data Red Book [11]. In recent years, many new plant species have been recorded and described here, such as *Aporosa tetragona* [12], *Eustigma honbaense* [13], *Tacca khanhhoaensis* [14], *Calophyllum honbaense* [15], etc. This reserve is located in the South-West of the world-famous Nhatrang city and is the homeland of various flora and fauna. But recently, the area's vegetation came under multiple stresses due to anthropogenic factors. Rapid deforestation made it possible that many of the critical plants may have become extinct before even being documented. Hence, an urgent requirement for documentation of biodiversity was felt. A review of literature and herbarium consultations revealed that apart from some preliminary species surveys, very little was known about the plant diversity of Hon Ba, and no systematic documentation of the plants occurring in reserve had been made so far [12]. Therefore, this study aims to determine the species diversity, value, and distribution of the Rubiaceae as a foundation for proposing solutions to the management and conservation sustainability of the Rubiaceae family plant resources in the study area.

## 2. Material and methods

### 2.1. Study area

This study was conducted from May to November 2017, June 2018, and October 2021 in Hon Ba Nature Reserve, Khanh Hoa province (from $12^0$01’45’’ to $12^0$12’00’’ North latitude and $108^0$53’45’’ to $109^0$02’34” longitude). The terrain was hazardous and complex, divided by many rivers and streams, creating beautiful rapids; most slopes were famous from $15^0$ to $40^0$ [12]. It was considered the only model in Vietnam with a relatively primitive structure of plant communities and forest landscape from 150 m to 1,578 m in a space not too wide and close to the sea. Moreover, this is the territory adjacent to the Bidoup massif of the Central Highlands. So it contains many unique values of biodiversity, forest, and landscape layers [16]. The top of Hon Ba had the properties of a medium mountain subtropical climate, the absolute maximum temperature was about $27^0$C, and the absolute minimum was $6.5^0$C. The average annual air humidity was over 85%, and the fog appears almost yearly, especially from September to December. The average annual rainfall was 1.900 mm to 2.000 mm [12]. The diversity of terrain and climate create the condition of forming forest types (vegetation). Different sub-types create the plant biodiversity in general and Rubiaceae species diversity in particular.

### 2.2. Methodology

#### *2.2.1. Sampling*

A total of 24 sample plots were established with an area of 10 m × 50 m and were characterized by the altitude and forest status. In which 16 sample plots were set up at each altitude of below 200 m, 201 m - 400 m, 401 m - 600 m, 601 m - 800 m, 801 m - 1000 m, 1001 m - 1200 m, 1201 m - 1400 m, above 1400 m and 8 sample plots of 4 forest status to collect the sample of Rubiaceae. Each plot was sampled, and the area remained constant [17-18]. Specific data on species quantity, composition, life-form spectrum, use-value, and phytogeographical factors was recorded based on specialized data.

#### *2.2.2. Data analysis*

Specimens were collected according to the research method of Thin NN (1997) [17]. Species identification by morphological comparison method based on the identification keys, the description in the documents of Ho PH (1999-2003) [5], and samples of specimens kept in Hon Ba Nature Reserve. The scientific name of the plants was determined and updated by Plants of the World Online (2021) [19] and World flora online (2021) [20]. The species list was established by Brummitt's method [21]; The life-form spectrum was determined by Raunkiær's classification scale [22]; Phytogeographical factors were assessed according to Pocs T (1965) [23]. The use-value of species plant was determined based on the documents: Vietnamese medicinal plant dictionary [24], Medicinal plants and medicine in Vietnam [25], an illustrated Flora of Vietnam [5], and 1900 helpful tree species in Vietnam [26]. Determine the distribution of species by altitude: This study used GPS to determine each species' coordinates and elevation combined with Excel to synthesize and analyze data. The scientific base for dividing eight elevation belts: < 201m, 201 - 400m, 401 - 600m, 601 - 800m, 801 - 1000m, 1001 - 1200m, 1201 - 1400m, and over 1401m based on the document Forest vegetation in Vietnam [27], in the South, when the altitude increased to 100 meters, the rule of reducing the temperature from 0.5-$1^0$C appeared. On the other hand, the preliminary survey results showed that the Rubiaceae distributed from

below 200 m to above 1400 m. This study determined the distance between the elevations belt was 200 m. They were assessing taxon diversity according to forest status: Based on the investigation results at the plot combined with the coordinates of species on transects, they analyzed the distribution of species by forest status. The conservation status of the plant species was determined based on the Vietnam Red Data Book (2007) [28], IUCN Red List (Updated 2021) [28], and Vietnam Red List of Medicinal Plants [29].

## 3. Results and discussion

### 3.1. Diversity of species component

*3.1.1. Species composition*

**Table 1** Species composition of Rubiaceae family

| No. | Scientific name | Life -form | Phytogeographical-factor | Use -value |
|---|---|---|---|---|
| **Genus 1. *Aidia* Lour**. | | | | |
| 1 | *Aidia cochinchinensis* Lour. | Mi | 3.1 | M, T |
| 2 | *Aidia oxyodonta* (Drake) T. Yamaz. | Mi | 6 | T |
| **Genus 2. *Argostemma* Wall.** | | | | |
| 3 | *Argostemma bariense* Pierre ex Pit. | Hp | 6 | |
| 4 | *Argostemma glabra* Joongku Lee, T. B. Tran & R.K. Choudhary | Hp | 6 | |
| 5 | *Argostemma uniflrum* Blume ex DC. | Hp | 4.2 | |
| 6 | *Argostemma verticillatum* Wall. ex Roxb. | Hp | 4 | |
| **Genus 3. *Brachytome* Hook.f.** | | | | |
| 7 | *Brachytome wallichii* Hook. f. | Mi | 4 | |
| **Genus 4. *Benkara* Adans.** | | | | |
| 8 | *Benkara armigera* (K.Schum.) Ridsdale | Mi | 4.1 | |
| 9 | *Benkara depauperata* (Drake) Ridsdale | Na | 6 | |
| 10 | *Benkara sinensis* (Lour.) Ridsdale | Na | 4.4 | |
| **Genus 5. *Caelospermum* Blume** | | | | |
| 11 | *Caelospermum truncatum* (Wall.) Baill. ex K. Schum. | Mi | 4.2 | M |
| **Genus 6. *Cephalanthus* L** | | | | |
| 12 | *Cephalanthus angustifolius* Lour. | Mi | 4.4 | |
| **Genus 7. *Coffea* L.** | | | | |
| 13 | *Coffea benghalensis* B.Heyne ex Roth | Mi | 4 | M |
| **Genus 8. *Discospermum* Dalzell** | | | | |
| 14 | *Discospermum quocensis* (Pierre ex Pit.) Arriola & A.P.Davis | Mi | 4.2 | T |
| **Genus 9. *Gaertnera Lam.*** | | | | |
| 15 | *Gaertnera junghuhniana* **Miq.** | Mi | 4.5 | |
| **Genus 10. *Gynochthodes* Blume** | | | | |
| 16 | *Gynochthodes cochinchinensis* (DC.) Razafim. & B.Bremer | Mi | 4.2 | M |

| | | | | |
|---|---|---|---|---|
| 17 | *Gynochthodes honbaensis* E.Oguri & Tagane | Mi | 6.3 | |
| 18 | *Gynochthodes lacunosa* (King & Gamble) Razafim. & B.Bremer | Lp | 4.2 | M |
| 19 | *Gynochthodes umbellata* (L.) Razafim. & B.Bremer | Lp | 3.1 | M, Dye |
| 20 | *Gynochthodes villosa* (Hook.f.) Razafim. & B.Bremer | Na | 4.2 | M |
| **Genus 11. *Guettarda* L.** | | | | |
| 21 | *Guettarda speciosa* L. | Mi | 3.2 | |
| **Genus 12. *Hedyotis* L.** | | | | |
| 22 | *Hedyotis acutangula* Champ. ex Benth. | Ch | 4.4 | |
| 23 | *Hedyotis auricularia* L. | Th | 3.1 | M |
| **Genus 13. *Hydnophytum* Jack** | | | | |
| 24 | *Hydnophytum formicarum* Jack | Ep | 4 | M |
| **Genus 14. *Hypobathrum* Blume** | | | | |
| 25 | *Hypobathrum hoaense* Pierre ex Pit. | Mi | 6 | |
| **Genus 15. *Ixora* L.** | | | | |
| 26 | *Ixora chinensis* Lam. | Na | 4.3 | M,Or |
| 27 | *Ixora coccinea* L. | Na | 4 | M, Or |
| 28 | *Ixora casei* Hance | Mi | 7 | Ed |
| **Genus 16. *Lasianthus* Jack** | | | | |
| 29 | *Lasianthus annamicus* Pit. | Na | 6 | |
| 30 | *Lasianthus chevalieri* Pit. | Na | 6 | |
| 31 | *Lasianthus chinensis* (Champ.) Benth. | Mi | 4.3 | |
| 32 | *Lasianthus cyanocarpus* Jack | Mi | 6 | |
| 33 | *Lasianthus eberhardtii* Pit. | Mi | 6 | |
| 34 | *Lasianthus foetidissimus* A. Chev. ex Pit. | Mi | 6 | |
| 35 | *Lasianthus hirsutus* (Roxb.) Merr. | Na | 4 | M |
| 36 | *Lasianthus hispidulus* (Drake) Pit. | Na | 6 | |
| 37 | *Lasianthus honbaensis* V.S. Dang, Tagane & H. Toyam | Na | 6.3 | |
| 38 | *Lasianthus kamputensis* Pierre ex Pit. | Mi | 4.5 | |
| 39 | *Lasianthus schmidtii* K.Schum. | Na | 4.5 | |
| 40 | *Lasianthus pierrei* Pit. | Na | 6 | |
| 41 | *Lasianthus inodorus* Blume | Na | 4.5 | |
| 42 | *Lasianthus verticillatus* (Lour.) Merr. | Na | 4.5 | |
| 43 | *Lasianthus yaharae V.S*. Dang, Tagae & H. Tran | Na | 6 | |
| **Genus 17. *Leptopetalum* Hook. & Arn.** | | | | |
| 44 | *Leptopetalum pteritum* (Blume) Neupane & N.Wikstr. | Ch | 4 | |
| **Genus 18. *Morinda* L.** | | | | |
| 45 | *Morinda citrifolia* L. | Mi | 4.2 | M, Dye |

| | | | | |
|---|---|---|---|---|
| **Genus 19. *Mussaenda* Burm. ex L.** | | | | |
| 46 | *Mussaenda bonii* Pit. | Lp | 4.5 | |
| 47 | *Mussaenda cambodiana* Pierre ex Pit. | Lp | 4.5 | M, Ed |
| 48 | *Mussaenda chevalieri* Pit. | Na | 6 | |
| 49 | *Mussaenda dinhensis* Pierre ex Pit. | Na | 6 | |
| 50 | *Mussaenda frondosa* L. | Mi | 4 | M |
| 51 | *Mussaenda glabra* Vahl | Lp | 4 | M |
| 52 | *Mussaenda recurvate* Naiki, Tagane & Yahara | Na | 6 | |
| **Genus 20. *Mycetia* Reinw.** | | | | |
| 53 | *Mycetia effusa* (Pit.) Razafim. & B.Bremer | Na | 6 | |
| **Genus 21. *Myrmecodia* Jack** | | | | |
| 54 | *Myrmecodia tuberosa* Jack | Ep | 4.2 | M |
| **Genus 22. *Nauclea* L.** | | | | |
| 55 | *Nauclea orientalis* (L.) L. | Me | 4.2 | M, T |
| | Genus 23. *Neanotis* W.H.Lewis | | | |
| 56 | *Neanotis hirsuta* (L.f.) W.H.Lewis | Lp | 6 | |
| **Genus 24. *Neonauclea* Merr**. | | | | |
| 57 | *Neonauclea purpurea* (Roxb.) Merr. | Me | 4.2 | T |
| **Genus 25. *Oldenlandia* L.** | | | | |
| 58 | *Oldenlandia grandis* Pit. | Lp | 6 | |
| 59 | *Oldenlandia leptoneura* Pit. | Lp | 6 | |
| 60 | *Oldenlandia quocensis* Pierre ex Pit. | Ch | 4.5 | |
| 61 | *Oldenlandia umbellata* L. | Lp | 3.2 | M |
| **Genus 26. *Ophiorrhiza* L.** | | | | |
| 62 | *Ophiorrhiza baviensis* Drake | Na | 6 | |
| 63 | *Ophiorrhiza sanguinea* Blume | Na | 4.2 | |
| **Genus 27. *Paederia* L.** | | | | |
| 64 | *Paederia foetida* L. | Lp | 4 | M, Ed |
| **Genus 28. *Pavetta* L.** | | | | |
| 65 | *Pavetta bauchei* Bremek. | Mi | 6 | |
| 66 | *Pavetta cambodiensis* Bremek. | Mi | 4.1 | |
| 67 | *Pavetta hongkongensis* Bremek. | Mi | 4.4 | |
| 68 | *Pavetta nervosa* Craib | Mi | 4.2 | |
| **Genus 29. *Prismatomeris* Thwaites** | | | | |
| 69 | *Prismatomeris tetrandra* (Roxb.) K. Schum. | Mi | 4.1 | M |
| **Genus 30. *Psychotria* L.** | | | | |
| 70 | *Psychotria asiatica* L. | Na | 4 | M |
| 71 | *Psychotria langbianensis* Wernham | Na | 6 | |

| | | | | |
|---|---|---|---|---|
| 72 | *Psychotria serpens* L. | Lp | 4.1 | M |
| **Genus 31. *Psydrax* Gaertn.** | | | | |
| 73 | *Psydrax dicoccos* Gaertn. | Mi | 4.4 | M, Ed |
| 74 | *Psydrax umbellatus* (Wight) Bridson | Mi | 4 | T |
| **Genus 32. *Pyrostria* Comm. ex A.Juss.** | | | | |
| 75 | *Pyrostria cochinchinensis* (Pierre ex Pit.) Utteridge & A.P.Davis | Mi | 6 | |
| **Genus 33. *Ridsdalea* J.T.Pereira & K.M.Wong** | | | | |
| 76 | *Ridsdalea vietnamensis* (Tirveng.) J.T.Pereira | Mi | 6 | |
| **Genus 34. *Saprosma* Blume** | | | | |
| 77 | *Saprosma chevalieri* Pit. | Mi | 6 | |
| 78 | *Saprosma gracile* Pit. | Mi | 6 | |
| 79 | *Saprosma longifolium* Pit. | Mi | 6 | |
| 80 | *Saprosma verrucosum* Pit. | Mi | 6 | |
| **Genus 35. *Scleromitrion* (Wight & Arn.) Meisn.** | | | | |
| 81 | *Scleromitrion verticillatum* (L.) R.J.Wang | Ch | 6 | |
| **Genus 36. *Tarenna*** | | | | |
| 82 | *Tarenna annamensis* Pit. | Mi | 6 | |
| 83 | *Tarenna attenuata* (Hook. f.) Hutch. | Mi | 4.2 | |
| 84 | *Tarenna aurantiaca* Naiki & Tagane | Na | 6 | |
| **Genus 37. *Tarennoidea* Tirveng. & Sastre** | | | | |
| 85 | *Tarennoidea wallichii* (Hook.f.) Tirveng. & Sastre | Mi | 4.2 | |
| **Genus 38. *Uncaria* Schreb.** | | | | |
| 86 | *Uncaria lanosa* var. *ferrea* (Blume) Ridsdale | Lp | 4.2 | |
| 87 | *Uncaria scandens* (Sm.) Wall. | Lp | *4.2* | |
| **Genus 39. *Urophyllum* Wall.** | | | | |
| 88 | *Urophyllum argenteum* Pit. | Mi | 6 | |
| 89 | *Urophyllum chinense* Merr. & Chun | Mi | 4.2 | |
| 90 | *Urophyllum villosum* Wall. | Mi | 4.2 | |
| **Genus 40. *Vidalasia* Tirveng.** | | | | |
| 91 | *Vidalasia tonkinensis* (Pit.) Tirveng. | Mi | 6 | Dye |
| **Genus 41. *Wendlandia* Bartl. ex DC.** | | | | |
| 92 | *Wendlandia glabrata* DC. | Mi | 4.2 | |
| 93 | *Wendlandia paedicalyx* Pit. | Mi | 6 | |
| **Genus 42. *Xanthophytum* Reinw. ex Blume** | | | | |
| 94 | *Xanthophytum polyanthum* Pit. | Mi | 6 | |

Note- Life-form: Phanerophytes (Ph); Therophytes (Th); Chamaephytes (Ch); Liano - phanerophytes (Lp); Nano - phanerophytes (Na); Micro - phanerophytes (Mi); Meso - phanerophytes (Me); Epiphytes (Ep); Phytogeographical factors: 3.1- Tropical Asia and Australia; 3.2- Tropical Asia and Africa; 4- Asian tropical element; 4.1- Indochina - Malesia; 4.2- Indochina - India; 4.3- Indochina - Himalaya; 4.4- Indochina - South China; 4.5- Indochina; 6-Endemic to Vietnam; 7-Crops; Use-value: M-Medicinal, Ed-Edible plants; Or- Ornamental; T-Timber.

Ninety-four species, 42 genera belonging to the Rubiaceae, were recorded at Hon Ba Nature Reserve, Khanh Hoa Province (Table 1).

The number of species distributed in each genus was uneven. The most diverse genera (from 5 species) were *Lasianthus*, 15 species (15.96%), *Mussaenda*, seven species (7.45%), and *Gynochthodes*, five species (5.32%). The genus *Pavetta, Argostemma, Oldenlandia,* and *Saprosma* with the same four species (the same 4.26%); *Ixora, Urophyllum, Tarenna, Psychotria, Benkara*, the same three species (the same 3.19%); *Aidia, Hedyotis, Ophiorrhiza, Psydrax, Uncaria,* and *Wendlandia* the same two species (the same 2.13%); and 24 single species-genera (the same 1.06%) (Table 1).

Among them, five new species were reported and described from 2015 to 2019, including *Lasianthus yaharae* [30], *Lasianthus honbaensis* [31], *Mussaenda recurvate* [32], *Tarenna aurantiaca* [33], *Gynochthodes honbaensis* [34]. A new record species for the Vietnamese flora was *Gaertnera junghuhniana* [35]. *Lasianthus honbaensis* and *Gynochthodes honbaensis* were endemic to Hon Ba Nature Reserve.

**Table 2** Comparison of Rubiaceae in Hon Ba with other regions and Vietnam

| Taxon | | Chau Hoan[1] | Dien Lam[1] | Lo Go-Xa Mat[2] | *This study* | Viet Nam[3] |
|---|---|---|---|---|---|---|
| Rubiaceae | Genera | 21 | 21 | 18 | *42* | 90 |
| | Species | 60 | 56 | 32 | *94* | 450 |

Notes: [1]Tu NT et al, 2015 [7]; [2]Nga NT, 2014 [8]; [3]Ban NT, 1997 [4];

The diversity of species and genera composition of Rubiaceae in Hon Ba is the highest, followed by Chau Hoan and Dien Lam communes; the lowest was Lo Go-Xa Mat National Park. In this study, the quantity of genera and species accounts for 46.67% and 20.89% of Rubiaceae in Vietnam. The high elevation range elucidated this diversity from 200 m to 1578 m; the terrain consists of many continuous mountains divided by rivers and streams, creating a diversity of terrain, combined with variable climatic zones change from tropical-subtropical.

*3.1.2. Diversity of the phytogeographical factor*

The results of determining the phytogeographical factors of the Rubiaceae family at Hon Ba Nature Reserve are summarized in Table 3.

**Table 3** The phytogeographical factors

| No. | Phytogeographical element | Abbreviation | No. of species | Percentage (%) |
|---|---|---|---|---|
| 1 | Tropical Asia and Australia | 3.1 | 3 | 3.19 |
| 2 | Tropical Asia and Africa | 3.2 | 2 | 2.13 |
| 3 | Asian tropical element (Indo-Malesian) | 4 | 12 | 12.77 |
| 4 | Indochina – Malesia | 4.1 | 4 | 4.26 |
| 5 | Indochina – India | 4.2 | 19 | 20.21 |
| 6 | Indochina – Himalaya | 4.3 | 2 | 2.13 |
| 7 | Indochina - South China | 4.4 | 5 | 5.32 |
| 8 | Indochina | 4.5 | 8 | 8.51 |
| 9 | Endemic to Vietnam | 6 | 36 | 38.30 |
| 10 | Endemic to the Hon Ba | 6.3 | 2 | 2.13 |
| 11 | Crop | 7 | 1 | 1.06 |

The Rubiaceae was diverse in phytogeographical factors, with 11 elements identified. In which the endemic factor of Vietnam accounted for the highest (38.30%), followed by Indochina - India (20.21%); Asian tropical element (Indo-Malesian) (12.77%); Indochina (8.51%); and the lowest were crop factor (1.06%). Among them, species endemic to Hon

Ba Nature Reserve were found, such as *Lasianthus honbaensis* [31] and, *Gynochthodes honbaensis* [34], *Hypobathrum hoaense*.

*3.1.3. Diversity of life-forms spectrum*

The diversity of the life-form spectrum was summarized in Table 4.

**Table 4** Diversity of life-forms spectrum

| Life-form | Phanerophytes (Ph) | Chamaephytes (Ch) | Therophytes (Th) |
|---|---|---|---|
| No. of species | 89 | 4 | 1 |
| Percentage (%) | 94.68 | 4.26 | 1.06 |

The Rubiaceae life-forms spectrum consists of three main life-forms. The Phanerophytes account for the highest (94.68%), followed by Chamaephytes (4.26%); and Therophytes (1.06%). Therefore, the Spectrum of Biology (SB) as follows: SB = 94.68Ph + 4.26Ch + 1.06Th. The species mainly timber, shrubs or sub-shrubs, sometimes herbaceous or vines, which are the main component created on the lower floor of the forest canopy floor [24].

### 3.2. Value of Rubiaceae

*3.2.1. Diversity of use-values*

The Rubiaceae family varied in composition, life-form spectrum, phytogeographical factors, and use value (Table 5).

**Table 5** Diversity of use-values

| No. | Use-value | No. of species | Percentage (%) |
|---|---|---|---|
| 1 | Medicinal | 24 | 25.53 |
| 2 | Timber | 6 | 6.38 |
| 3 | Edible plant | 4 | 4.26 |
| 4 | Dye | 3 | 3.19 |
| 5 | Other groups (poison, ornamental) | 2 | 2.13 |
| | Total | 39 | 41.49 |

The medicinal plants had the highest number of species (25.53%), followed by the timber (6.38%), edible plants (4.26%), the dyes (3.19%), and other user groups had the lowest number of species (2.13%). Thus, the medicinal plants dominate, such as *Gynochthodes umbellata, Morinda citrifolia, Myrmecodia tuberosa, Hydnophytum formicarum*, etc. [7]. Many were used in many areas of human life, such as the study of medicine, food, dyeing, woodworking industry, etc. [24].

*3.2.2. Composition of threatened species*

We have identified the composition of the threatened species of the Rubiaceae (Table 6).

A total of 12 threatened species were listed in the Vietnam Red Data Book (2007), Vietnam Red List of medicinal plants (2019), and IUCN Red List (2021). Of them, five species at the VU and one species at EN were listed in Vietnam Red Data Book (2007); one species at EN and one species at VU in the Vietnam Red List of medicinal plants (2019); and six species at LC and one species at VU in IUCN Red List (2021).

**Table 6** Composition of threatened species

| No. | Vietnamese name | Scientific name | VNRDB (2007) | VNRMP (2019) | IUCN (2021) |
|---|---|---|---|---|---|
| 1 | Găng nam bộ | *Aidia cochinchinensis* Lour. | | | LC |
| 2 | Găng nghèo | *Benkara depauperata* (Drake) Ridsdale | VU | | |
| 3 | Găng trung quốc | *Benkara sinensis* (Lour.) Ridsdale | | | LC |
| 4 | Gạt bao | *Gaertnera junghuhniana* Miq. | | | LC |
| 5 | Lâm bòng | *Guettarda speciosa* L. | | | LC |
| 6 | Xuân tôn phú quốc | *Xantonnea quocensis* Pierre ex Pitard | VU | | |
| 7 | Ổ kiến gai | *Myrmecodia tuberosa* Jack | VU | VU | |
| 8 | Gáo vàng | *Nauclea orientalis* (L.) L. | | | LC |
| 9 | Giọt sành hồng kông | *Pavetta hongkongensis* Bremek. | | | LC |
| 10 | Xương cá | *Psydrax dicoccos* Gaertn. | VU | | VU |
| 11 | Kỳ nam | *Hydnophytum formicarum* Jack | EN | EN | |
| 12 | Dành dành việt nam | *Ridsdalea vietnamensis* (Tirveng.) J.T.Pereira | VU | | |

**Note:** VNRDB (2007): Vietnam Red Data Book (2007); VNRMP (2019): Vietnam Red List of Medicinal Plants (2019); En: Endangered; Vu: Vulnerable; LC: Least Concern.

### 3.3. Distribution of Rubiaceae

*3.3.1. Distribution of species according to altitude*

Figure 1 shows that the number of genera increases as the altitude increases, peaks at an altitude of 401 m-600 m with 30 genera (78.95%), and then decreases as the altitude increases. The species distribution also has a gradually increasing rule, but the peak is at 200 m-400 m with 64 species (64.65%), then decreases as elevation increases.

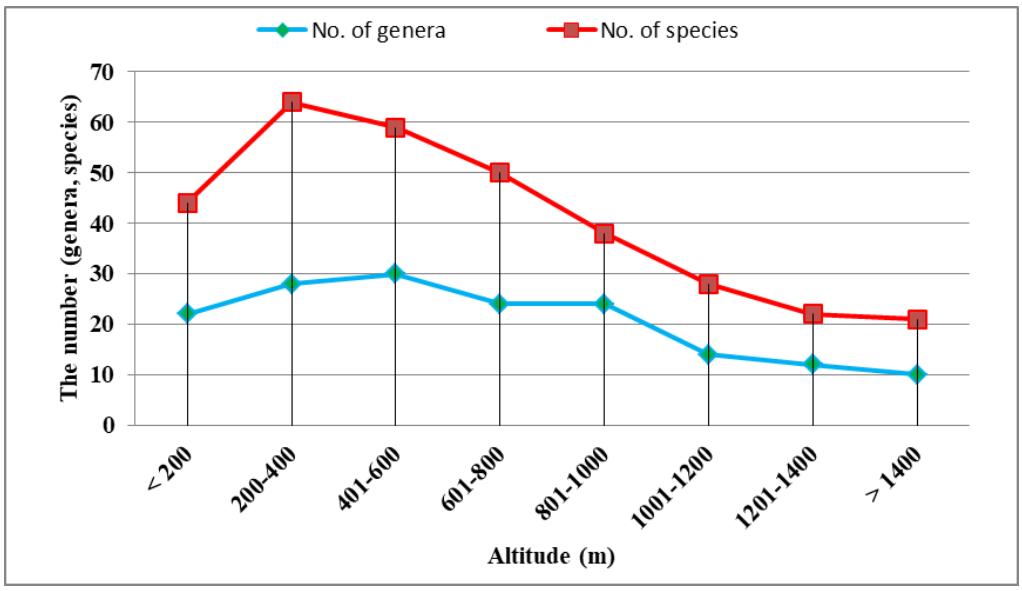


**Figure 1** The rule of distribution of the species by altitude

Several theories have been proposed to describe species richness patterns and the narrow bands of the vertical gradient, but no definite pattern has emerged [36]. Almost all previous studies have documented that the altitude a.s.l, the lower

the quantity and richness [37-38]. This result was explained by the elevation below 200 m affected by human activities, leading to lower richness. The concentration distribution of Rubiaceae species at elevations belt 200 m - 400 m showed the importance of protecting plant diversity and preserving plant resources in this elevation band.

*3.3.2. Distribution of species according to forest status*

We identified the plant distribution in 4 forest states: poor, medium, rich, and very rich forests (Table 7).

The state of the medium forest had the highest number (percentage) of genera and species, followed by poor, rich, and very rich forests, the lowest (Table 5). The results of this study were explained by the poor forest and frequent situations of illegal exploited activities by local people. Rubiaceae species were sensitive to disturbance in the tropical regions and were found in secondary forest types [39]. Meanwhile, the rich and very rich forests distributed where high altitudes, without being influenced by the activating of humans, but they belong to climate subtropical and temperate. The family was less frequent and diverse but widespread in temperate regions [2].

**Table 7** Species distribution according to forest status

| No. | Forest status | Genera | | Species | |
|---|---|---|---|---|---|
| | | Number | Percentage (%) | Number | Percentage (%) |
| 1 | Poor | 34 | 80.95 | 65 | 69.15 |
| 2 | Medium | 38 | 90.48 | 78 | 82.98 |
| 3 | Rich | 17 | 40.48 | 35 | 37.23 |
| 4 | Very rich | 10 | 23.81 | 19 | 20.21 |

## 4. Conclusion

Rubiaceae family at Hon Ba Nature Reserve were diverse and abundant in species component, threatened species, phytogeographical factors, life-form spectrum, and use-value. 12 threatened species listed in Vietnam Red Data Book) 2007), IUCN Red List (2021), Vietnam Red List of Medicinal plants (2019). Most species belonging to the Rubiaceae were endemic to Vietnam. Phanerophytes were the dominant life form of the Rubiaceae. Thirty-nine species were found for use-value; the medicinal plants accounted for the highest proportion. The number of genera and species increases with increasing altitude and peaks and decreases. Four forest states, including poor, medium, rich, and very rich forests, were identified had species of Rubiaceae. In which the medium forest had several species and genera diversity.

## Compliance with ethical standards

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*Disclosure of conflict of interest*

The authors declare no conflict of interest.

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