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**HIGHLAND VEGETATION AND FLORA OF VAN BAN DISTRICT,  
LAO CAI PROVINCE IN NORTHERN VIET NAM**

**ФЛОРА И РАСТИТЕЛЬНОСТЬ ВЫСОКОГОРИЙ ПРОВИНЦИИ ЛАО КАЙ  
СЕВЕРНОГО ВЬЕТНАМА**

A short survey of the flora and vegetation of Lang Cung Mountains located in Van Ban District, Lao Cai Province in northern Viet Nam is compiled on the base of original data obtained from field work conducted during 2001–2002. Description of main types of plant communities and brief analysis of the flora are based on model plot descriptions and extensive herbarium collections. Closed evergreen tropical monsoon (seasonal) forest is the main vegetation type in the studied area. This formation is subdivided into lowland, submontane, lower montane and upper montane forests, which are described in detail. The characteristics of vegetation and taxonomic composition of the studied flora are typical for southeastern extension of montane uplands of Sikang-Yunnan floristic province in the limits of Hoang Lien Son Range. This flora represents a derivative of ancient Tertiary flora, which includes a great number of archaic genera common to Europe and East Asia during Upper Cretaceous and Lower Tertiary. In reference to its origin and composition, this flora represents unique relictual formation, which may serve as a model for the study of extinct floras that were once widely distributed in the Northern Hemisphere during the Tertiary.

**Introduction**

The northwestern part of Viet Nam is a mountainous area with a number of high ranges coming from northwest to southeastern direction. The largest mountain formation of this region is the Hoang Lien Son Range. It represents the southeastern extension of the Himalayas, which extends from Yunnan into northern Viet Nam. This range forms in northwestern part of Viet Nam a large, clear, outlined, and distinct mountainous region, which appears as a vast area of uplands, extending above 1600–2000 m with a number of peaks reaching 2500–3000 m a.s.l. The highest peaks in mainland Southeast Asia, such as Fan Si Pan (3143 m) and Lang Cung (2913 m), are located here. Most of highest mountain formations of Hoang Lien Son Range consist of huge granite or quartzite intrusions of late Mesozoic age.

The highland area associated with Hoang Lien Son Range is outlined in modern biogeography as the southeastern part of Sikang-Yunnan floristic province of Holarctic floristic kingdom (Takhtajan, 1978, 1986; Averyanov, et al., 2003). This region lies on the border of Holarctic and Paleotropic realms and represents a very important boundary area with numerous tropical, subtropical, and temperate floristic connections, studies

of which explain the many aspects of historical formation and development of modern floras of Southeast Asia and Indochinese Peninsula. At the same time local endemism in Sikang-Yunnan floristic province is very high (Averyanov, 2002a, 2002b; Averyanov, et al., 2002, 2003), which makes this flora one of the richest and specific indigenous floras of mainland Asia. Investigations on the flora of Sikang-Yunnan floristic province represent outstanding fundamental scientific interest. Nevertheless, it is very far from being a complete, adoptable and reasonable inventory. Few acceptable botanical surveys exist for the Vietnamese portion of the Sikang-Yunnan floristic province. The meager published works on the flora of Fan Si Pan Mountains are still being used for all the vast territory of Hoang Lien Son Range (Nguyen Nghia Thin, Harder, 1996; Nguyen Nghia Thin, 1998; Nguyen Nghia Thin, Nguyen Thi Thoi, 1998). Some fragments of basic botanical data could be found in general fundamental taxonomic publications on the flora of Vietnam, such as “Flore Generale de l’Indochine” (ed. M.H. Lecomte, H. Humbert, 1907–1951), “Flore du Cambodge, du Laos et du Viet-Nam” (ed. A. Aubreville, J.F. Leroy, Ph. Morat, 1960–1997), “An illustrated flora of South Viet-Nam” and “An illustrated flora of Vietnam” (Pham Hoang Ho, 1970–1972; 1991–1993; 1999–2000), “Vascular plant synopsis of Vietnamese flora” (ed. L. Averyanov et al., 1990, 1996) and in a number of recent floristic and taxonomical papers and monographs (Seidenfaden, 1975, 1992; Averyanov, 1988, 1989, 1990a,b, 1994, 1998, 1999a,c, 2000a,b, 2002c-e; Vu Van Dung, 1996; Nguyen Nghia Thin, 1997, 1999; Averyanov and Averyanova, 2000, 2003; Averyanov, Phan Ke Loc, 2002; Averyanov et al., 2002, 2003; Vu Ngoc Long, Averyanov, 2002 and some others)<sup>1</sup>. However, the vast highland area of Hoang Lien Son Range with its very rich endemic indigenous flora and unique montane types of vegetation remains up to now botanically unexplored and undocumented.

At the same time, it is very important to emphasize that deforestation, degradation, and destruction of natural habitats are presently widespread all over wide areas of the Hoang Lien Son Range. In this critical situation, urgent botanical investigations in this region are very important for providing sound scientific data for the protection of the forests and conservation of still remaining primary unique plant communities, that have worldwide significance as centers of outstanding plant diversity.

The southern part of Van Ban District along border of Lao Cai and Yen Bai Provinces was selected as the study area for a number of reasons. First, it still has relatively large, pristine, highland mountain forests, which represent typical mountain vegetation of the southern part of Hoang Lien Son Range. Second, it is a very important refugium for numerous indigenous animal species. Third, there is a proposal to designate the area as a very important protected nature reserve in Viet Nam.

## Materials and methods

The general outline of original primary flora and vegetation, as well as description

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<sup>1</sup> Bibliographies of published studies of the Indochina flora have been published, each covering sequential periods of time by Petelot (1955), Vidal (1972) and Vidal et al. (1988, 1994).

of most typical primary zonal and azonal plant communities were made at 700–2640 m elevation during field work in southern part of Van Ban District, Lao Cai Province of northern Viet Nam in September–October 2001 and in March 2002.

The description of forest structure and taxonomic composition of vegetation types and plant communities was made along landscape profiles (transects) from lowest to highest elevation starting from the lowest mountain belt where primary forests were observed. Various kinds of secondary plant formations, that represents different stages of degradation of primary plant communities (various kinds of secondary forests, secondary shrubs, secondary grasslands, weed and ruderal plant communities, etc.) were not studied and not included in this paper.

The description of vegetation was based on field observations along landscape transects and detailed descriptions of forest structure and species composition in temporary plots, selected at different elevations in most typical and representative plant communities. Selected plots varied in size from 10×10 m (for herb or cliff lithophytic plant communities) to 20×50 m (for high forest formations). The size of selected plots depended on the largest possible size of land available with rather uniform, homogeneous vegetation cover. Model plots were selected in all types of primary plant communities, which were observed along studied landscape profiles and transects.

The size of model plots commonly used for description of species composition and vegetation of forest formations was 20×40 m. For each plot were measured the geographical coordinates, elevation above sea level, slope exposure and inclination. In this work were used standard GPS receiver, altimeter, compass and topographic maps (1:50000). In each plot were briefly described features of leaf litter, main soil horizons and parent rocks. Vegetation structure was described for each distinctly observed stratum with determination of projective coverage and taxonomic composition for each storey (including herb and moss/lichens strata). Detailed descriptions of non-strata component of plant communities – epiphytic, lithophytic, climber and vine plants, as well as plants of specific life forms, such as root and canopy parasites, mycotrophic achlorophyllous herbs, etc. were provided for each model plot with determination of dominant species. Special attention in field studies was given to the orchids (Orchidaceae) and gymnosperm species (Cupressaceae, Pinaceae, Podocarpaceae, Taxodiaceae). Number of tree boles with their diameter for each tree strata were given forest descriptions for each plot. The diameter of the tree bole was measured at breast height about 1.5 m above the ground.

Additional important information on vegetation structure and species composition of primary plant communities in the studied area was obtained from field observations and plant collections during numerous extensive botanical explorations done on foot in the studied mountains.

The descriptions of vegetation and plant communities were entered in standard form. Each name in these descriptions were based on voucher herbarium specimens, which are housed with appropriate collecting number<sup>2</sup> and name in Herbaria at the Institute of Ecology and Biological Resources of the National Center for Natural Science and Technology of Viet Nam (HN), Royal Botanical Gardens, Kew (K), Komarov

Botanical Institute of the Russian Academy of Sciences (LE) and Missouri Botanical Garden (MO). Flowers of the most important, rare and scientifically significant species were also collected in alcohol (in addition to herbarium material) and were deposited at HN. Photographs of typical and most significant plants of studied area were also made and copied onto CD-ROM.

### **Geography and geology of the studied area**

Geographically and geologically, Hoang Lien Son Range and associated highland mountain areas represent the farthest SSE extension of Himalayan uplands and therefore have similar origin, structure and rock composition. The extreme southeastern portion of Hoang Lien Son Range is marked by Lang Cung mountain system. The highest peak of this system reaching 2913 m lies on the border of Lao Cai and Yen Bai Provinces. The northern branches of this mountain system that are generally north-faced slopes represent large highland area that occupies southern part of Van Ban District between 21°54'–22°01' N latitude and 103°57'–104°22' E longitude. This upland area extends in the region from the NWW to the SEE to about 40 km ranging in width from 6 to 18 km.

Generally, mountain systems here are composed of magmatic silicate rocks particularly granite and quartzite, which were formed as extensive intrusions of late Paleozoic and Mesozoic ages (Dovzikov et al., 1965a, b). According to our observations, large mountain formations in the studied area are also composed of solid, highly pressed, deeply metamorphosed sandstone with high amount of silicates consolidated with more or less large numerous quartzite dikes. Pure white quartzite is also a common kind of rock that comprised the highland of Van Ban District. Tertiary tectonic movements uplifted these mountain terrains up to present-day elevations and succeeding erosion processes formed the present-day characteristic rocky landscape of this highland area with very steep slopes, numerous rocky cliffs and deep narrow river canyons (Schzeglova, 1957; Fridland, 1961; Rundel, 1999; Averyanov, et al., 2003).

The remnant rocky hills and mesas comprised of eroded solid crystalline limestone of presumably late Paleozoic or early Mesozoic ages are widely observed in the lowland areas of Van Ban District outside of the study area.

### **Climate**

A monsoon tropical climate associated with mountains is typical of Viet Nam in mountain areas higher than 1400–1500 m a.s.l. (Nguyen Khanh Van, et al., 2000). Such climate is spread across the largest mountain ranges of the northern Viet Nam including Hoang Lien Son Range. Accordingly, this type of climate is also observed in the highland areas of Lang Cung mountain system in the southern part of Van Ban District. However, there exists few verifiable scientific data on this type of climate for

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<sup>2</sup> For herbarium collecting numbers in this expedition is used index “**HAL**”, which represent abbreviation of names of main participants of this project – Nguyen Tien **H**iep, Leonid Averyanov and Phan Ke **L**oc (HAL2001-2846).

the highland mountain areas in Viet Nam.

Basically, a humid climate with rainy warm summers and cold foggy and misty winters without a distinct dry period is typical for Van Ban highland area. The mean annual amount of precipitation according to meteorological data from the nearest comparable stations ranges from 2833 mm in Sa Pa town (22°20'N, 103°50'E, elev. 1570 m a.s.l.) to 3552 mm in Hoang Lien Son station (22°21'N, 103°46'E, elev. 2170 m a.s.l.) in the mountain regions of Hoang Lien Son Range to the NW of the studied area. The peak of rainfall comes here in the summer months. However no distinct dry period can be observed in this region. Morning dew is very common throughout mountain zone, as well as frequent heavy foggy mist. Humidity and amount of rainfall essentially increase with elevation in the mountains. Humid cold NE monsoon winds that bring heavy fog, mist and drizzling rain are very common here in the winter and early spring. They provide relatively high humidity on east and northeast facing mountain slopes, while much more dry habitat conditions may be regularly seen in the studied area on slopes of southwest exposure.

Temperature regime normally depends on elevation. The mean annual temperature at the nearest climate stations in Sa Pa weather station at 1570 m is 15.2°C, while it is 12.8°C in Hoang Lien Son at 2170 m a.s.l. Summer temperatures in these regions are usually around 16–20°C and winter temperatures regularly vary from 7–10°C. The absolute minimal temperature reported in mountains of Hoang Lien Son Range at elev. 2170 m a.s.l. is -5.7°C. Occasional wet snow and hail may be expected in the mountains of Van Ban District coldest winter months at elevations higher than 2000 m a.s.l. The maximum temperature recorded at this elevation is 24.9°C.

Considerable temperature variation connected with landscape elevation results in formation of clear altitudinal zones of vegetation in mountain regions of Hoang Lien Son Range. Generally, the climate zone of monsoon tropical climate associated with mountains defines formation in highland montane regions of northern Viet Nam of distinct zonal belt of montane forests at elevations higher than (1400) 1600 m, while at lower elevations submontane and lowland forests are primarily developed (Nguyen Khanh Van et al., 2000). This scheme is in accordance with basic world-accepted international classification of vegetation (UNESCO, 1973).

Closed evergreen tropical broad-leaved, mixed and coniferous wet submontane and montane forests are the dominant primary types of vegetation in highland zone of southern part of Van Ban District in the studied area.

### **Survey of primary vegetation in the studied area**

Specific distribution of different climatic types, diverse soils, various geological structures and numerous geomorphologic forms, along with large range of landscape elevations lead to formation of four altitudinal zones with 4 main types of forests in the southern part of Van Ban District.

The primary zonal types of vegetation in the studied area belong to group of *closed evergreen tropical monsoon (seasonal) forests*, which have some modifications according to species composition of first forest stratum. The types of zonal primary

vegetation observed in southern part of Van Ban District are presented in Table 1. The distribution of dominant and associated tree species in canopy strata of these vegetation types is shown in Table 2. A number of azonal primary vegetation types that often have unusual plant communities with specific taxonomic composition rich in rare species are observed in each type of zonal vegetation. Such types of vegetation sometimes support very diverse and important habitats for many unique species of plants and animals. Among them are riparian vegetation that develops along stream and rivers, and lithophytic

Table 1

Types of primary zonal vegetation in southern part of Van Ban District

Name of formation	Elevation in m a.s.l.	Geomorphologic preference
<b>1. Closed evergreen tropical monsoon (seasonal) forests:</b>	0-2640	All available landscape forms
<b>1.1. Lowland forests:</b>	0-600	Not studied
<b>1.1.a. Broad-leaved forests</b>	0-600	Not studied
<b>1.2. Submontane forests:</b>	600-1400	All available landscape forms
<b>1.2.a. Broad-leaved forests</b>	600-1400	Lower and middle part of not too steep slopes
<b>1.2.b. Mixed forests</b>	600-1400	Upper part of more or less steep slopes
<b>1.2.c. Coniferous forests</b>	600-1400	Upper part of ridge slopes and tops of ridges
<b>1.3. Lower montane forests</b>	1400-2200	All available landscape forms
<b>1.3.a. Broad-leaved forests</b>	1400-2200	Lower and middle parts of not too steep slopes
<b>1.3.b. Mixed forests</b>	1400-2200	Upper part of more or less steep slopes
<b>1.3.c. Coniferous forests</b>	1400-2200	Upper part of ridge slopes and tops of ridges
<b>1.4. Upper montane forests</b>	2200-2640	All available landscape forms, but particularly on tops of ridges
<b>1.4.a. Broad-leaved forests</b>	2200-2640	Same

vegetation on open rocky outcrops and cliffs are very common in the studied area. Special attention was given to the study and description of such habitats during field work as localities of specific plant diversity of the area.

### Brief survey of the types of primary zonal vegetation in the studied area

#### 1.1. Closed evergreen tropical monsoon (seasonal) lowland forest [I.A.2a]<sup>3</sup>

This type of primary vegetation was represented on hills and mountain foothills at elevations 100–600 m a.s.l. Supposedly, broad-leaved warm loving forest formations were present in the past at these elevations in the studied area. This forest type is now completely extinct, being replaced in the area by secondary plant communities. Among them are the most common highly degraded open secondary forests, secondary stands of bamboo, secondary scrubs and grasslands. In the present study, these plant communities were not specifically studied.

<sup>3</sup> Index according to UNESCO classification (1973).

Table 2

Distribution of main dominant and co-dominant species of the first and second forest strata at different elevations in mountains of Van Ban District and main forest types in this area

Distribution of species at different elevations in the studied area  
(Elevation is expressed on the table as numbers in hundred meters)

	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
<i>Acer laurinum</i>																					
<i>Acer</i> sp.																					
<i>Actinodaphne</i> sp.																					
<i>Archidendron balansae</i>																					
<i>Artocarpus</i> sp.																					
<i>Arundinaria</i> sp.																					
<i>Canarium</i> sp.																					
<i>Carpinus</i> sp.																					
<i>Castanopsis</i> sp.																					
<i>Cinnamomum</i> sp.																					
<i>Cryptocarya</i> sp.																					
<i>Daerycarpus imbricatus</i>																					
<i>Dillenia</i> sp.																					
<i>Dipterocarpus retusus</i>																					
<i>Eberhardtia aurata</i>																					
<i>Elaeocarpus tonkinensis</i>																					
<i>Elaeocarpus</i> sp.																					
<i>Enkianthus</i> sp.																					
<i>Exbucklandia populnea</i>																					
<i>Ficus subincisa</i>																					
<i>Fokienia hodginsii</i>																					
<i>Gironniera subaequalis</i>																					
<i>Hopea mollissima</i>																					
<i>Illicium tsaii</i>																					
Lauraceae gen.sp.																					
<i>Lithocarpus</i> sp.																					
<i>Litsea</i> sp.																					
<i>Livistona</i> sp.																					
<i>Madhuca pasquieri</i>																					
<i>Magnolia</i> sp.																					
<i>Manglietia</i> sp.																					
<i>Meliosma lepidota</i>																					
<i>Michelia</i> sp.																					
<i>Nephelium milliferum</i>																					
<i>Paramichelia</i> sp.																					
<i>Pieris</i> sp.																					
<i>Quercus</i> sp.																					
<b><i>Rehderodendron macrocarpum</i></b>																					
<i>Rhododendron basilicum</i>																					
<i>Rh. cinnabarinum</i>																					
<i>Rh. cyanocarpum</i>																					
<i>Rh. ramsdenianum</i>																					
<i>Rh. wallichii</i>																					
<i>Rhododendron</i> sp.																					
<i>Rhodoleia championii</i>																					
<b><i>Rhoipteleia chiliantha</i></b>																					
Rosaceae gen.sp.																					
Sapindaceae gen.sp.																					
<i>Schefflera</i> sp.																					
<i>Schima wallichii</i>																					
<i>Chisocheton</i> sp.																					
<b><i>Sorbus</i></b> sp.																					
<i>Symplocos</i> sp.																					
<i>Syzygium</i> sp.																					
<i>Taiwania cryptomerioides</i>																					
<i>Tetrapanax papyrifera</i>																					
Theaceae gen.sp.																					
<i>Vaccinium</i> sp.																					
<i>Vatica</i> sp.																					
<i>Xanthophyllum urophyllum</i>																					
<b>Forest type:</b>	<b>1.2</b>							<b>1.3</b>							<b>1.4</b>						

**Note:** Species observed as co-dominants of the first or second forest stratum at respective elevation is marked in Table 2 with black shading; species occurring at these strata as associates are marked with gray. Names of deciduous species are written in bold font. Vertical columns (delimited with bold lines) indicate different types of primary forests typical for the mountains of Van Ban District area: 1.2 – Closed evergreen tropical monsoon (seasonal) submontane broad-leaved, mixed and coniferous forests, 1.3 – Closed evergreen tropical monsoon (seasonal) lower montane broad-leaved, mixed and coniferous forests, 1.4 – Closed evergreen tropical monsoon (seasonal) upper montane broad-leaved forest.

## 1.2. Closed evergreen tropical monsoon (seasonal) submontane forests [I.A.2b]

Remnant fragments of submontane forests may be found in the southern part of Van Ban District at elevations between 600 and 1400 m a.s.l. As main dominant trees of first forest stratum, warm-loving species appear to be common here. On level landscape formations, on not steep slopes, especially in the low and middle parts of mountain slopes are broad-leaved trees like *Castanopsis* sp., *Cinnamomum* sp., *Dipterocarpus retusus*, *Hopea molissima*, *Madhuca pasquieri*, *Syzygium* sp., *Vatica* sp., and warm loving species of *Lithocarpus* and *Quercus*. These trees reach 35–45 m high and form the first stratum of **closed evergreen tropical monsoon (seasonal) submontane broad-leaved forests**. Along tops of ridges, in upper part of mountain slopes, especially in dry conditions of more steep slopes, *Dacrycarpus imbricatus* appears as an important coniferous co-dominant in the first forest stratum. This tree together with the above mentioned broad-leaved trees form the **closed evergreen tropical monsoon (seasonal) submontane mixed forests**. Along relatively dry narrow and steep summits of ridges *Dacrycarpus imbricatus* occasionally may be observed as a single dominant of the first forest stratum forming **closed evergreen tropical monsoon (seasonal) submontane coniferous forests**. As the most common associates of the first and second forest strata that reach 25–30 m high in submontane forests appears numerous warm-loving broad-leaved trees, particularly: *Artocarpus* sp., *Canarium* sp., *Cryptocarya* sp., *Dillenia* sp., *Eberhardtia aurata*, *Elaeocarpus tonkinensis*, *Elaeocarpus* spp., *Girroniera subaequalis*, *Litsea* sp., *Michelia* spp., *Nephelium milliferum*, *Xanthophyllum urophyllum* and *Livistona* sp. (Table 2).

### 1.2.a. Closed evergreen tropical monsoon (seasonal) submontane broad-leaved forests [I.A.2b(1)]

**Altitudinal range in the studied area.** 600–1400 m a.s.l.

**Slope inclination and geomorphologic preference.** Commonly 3–40(45)°. Flat valleys, basal parts, lower, or middle parts of mountain slopes.

**Parent soil material.** Granite, quartzite and quartzite sandstone.

**Leaf litter.** From 3 to 12 cm (commonly 4–8 cm) thick, overlaid by layer of fragments of unidentifiable leaves and twigs 1.5–3 cm thick.

**Soil (depth of layer in cm from the surface).** 0–20 – 25 cm – dark-brown,



gray-brown or brown, distinctly friable, rich in humus; 20–25 – 35–50 cm – yellow-brown, sandy-clayey, friable; 35–50 – 90–110 cm – yellow-orange, clayey, with numerous pieces of quartzite; 90–110 – 130–150 – bright orange, sandy-clayey, solid, with orange red soft sandy concretions and pieces of weathered parent rocks; 130–150 cm and deeper – residuum of weathered granite, mixed with large pieces of quartzite placed on parent rocks.

**1st forest stratum (tree storey).** Common co-dominants (observed occasionally as oligo- or mono-dominants) are evergreen trees, such as *Dipterocarpus retusus*, *Hopea mollissima*, *Madhuca pasquieri*, *Castanopsis* sp. and *Michelia* spp. As occasional associates of first forest stratum are observed *Canarium album*, *Paramichelia* sp. and some representatives of Theaceae. Trees of this stratum reach (30–)40 – 45(–50) m high and (50–)70 – 100 cm in diameter. Projective coverage of this stratum varies in the studied area from (30–) 50 to 70%.

**2nd forest stratum (tree storey).** Most common co-dominants of this stratum in the studied area are evergreen trees like *Hopea mollissima*, *Lithocarpus* sp., and *Michelia* sp. As occasional associates are observed numerous evergreen trees, particularly species of *Artocarpus*, *Cryptocarya*, *Litsea*, *Quercus*, *Vatica*, *Gleditsia*, as well as *Gironniera subaequalis*, *Nephelium milliferum*, *Xanthophyllum urophyllum*, palm *Livistona* sp. Trees of this stratum commonly reach 20–35 m in high and 25 – 50(–60) cm in diameter. Projective coverage in this storey varies from 30 to 60%.

**3rd forest stratum (tree storey).** As occasional co-dominants of this stratum may appear a giant bamboo – *Dendrocalamus* sp. and a few species of evergreen trees such as *Adina* sp. and *Hopea mollissima*. Commonly domination of any species in this stratum is not clear and forest stands is represented by numerous evergreen species, among which were observed *Carallia brachiata*, *Elaeocarpus tonkinensis*, *Gironniera subaequalis*, *Knema globularia*, *Illicium majus*, numerous species of such genera as *Aglaiia*, *Antidesma*, *Cinnamomum*, *Cryptocarya*, *Dillenia*, *Garcinia*, *Schefflera* and many representatives of Annonaceae. Deciduous trees like *Acer laurinum* are also found here. Trees of this stratum usually reach 10–20 m tall and 10–25 cm in diameter. Projective coverage of their canopies varies from 20 to 50%.

**4th forest stratum (shrubs).** Height of this stratum ranges usually from 3 to 7 m tall. Most common co-dominant species here are evergreen shrubs and treelets like *Archidendron balansae*, *Aglaiia edulis*, *Cinnamomum* sp., *Microdesmis casearifolia*, *Oxydendron* sp., *Paralbizia* sp. and *Schefflera* sp. Large bamboo – *Dendrocalamus* sp. and woody fern – *Cyathea* sp. are also observed as common co-dominants of shrub stratum in this type of forest. Numerous other evergreen shrub and treelet species were found here as more or less regular associates of this forest stratum. Among them are *Aglaiia edulis*, *Archidendron balansae*, *Carallia brachiata*, *Cinnamomum* sp., *Garcinia* sp., *Macaranga* sp., *Meliosma lepidota*, *Nephelium milliferum*, *Oxydendron* sp., *Pseudodissochaeta septentrionalis*, *Randia* sp., *Schefflera* sp., *Syzygium* sp., numerous species of *Ardisia*, *Lasianthus*, *Tabernaemontana* and species of Annonaceae. Dwarf palm – *Licuala paradoxa*, middle tall bamboo and other giant herbs, such as *Musa* sp. are also common here, particularly in wet open places. Usual

projective coverage of this stratum varies from 20 to 30%.

**5th forest stratum (undershrubs and herbs).** Height of this stratum is less than 2 m. It includes numerous species of small shrubs, undershrubs and herbs. As more common co-dominants of this stratum were observed such shrubs as *Strobilanthes* sp., *Blastus cochinchinensis*, *B. multiflorus*, small palm *Licuala* sp. and woody fern *Cyathea podophylla*. Among herbs as co-dominant species were observed *Mapania* sp., *Mondopsis petelotii*, *Ophiopogon latifolius*, *Ophiopogon* sp., numerous species of Acanthaceae, as well as numerous terrestrial ferns like *Asplenium normale*, *Polystichum* spp. (3–4 species), *Tectaria* spp. (2 species) and selaginellas (*Selaginella* spp.).

A large number of species were observed in this stratum as occasional associates. Among them were:

Shrubs:

*Ardisia* spp. (2-4 species), *Dacrycarpus imbricatus* (juvenile), *Lasianthus* spp. (3-4 species),  
*Calamus* sp. (juvenile), *Ilex* sp. (juvenile), *Myrsine* sp.,  
*Dracaena* sp., *Ixora* sp., *Smilax* sp.

Herbs:

Acanthaceae gen. sp., *Costus speciosus*, *Pellionia* sp.,  
*Aglaonema* sp., *Curculigo* sp., *Pentaphragma sinense*,  
*Alpinia* spp. (2 species), *Elatostema* spp. (2-3 species), *Phrynium* sp.,  
*Amorphophallus* sp., *Floscopa* sp., *Pilea* sp.,  
*Anoectochilus roxburghii*, *Impatiens* sp., *Piper boehmeriaefolium*,  
*Apostasia wallichii*, *Liparis paradoxa*, *Piper* sp.,  
*Ardisia* spp. (3 species), *Mapania* spp. (2 species), *Scleria* sp.,  
*Aspidistra* sp., *Mischobulbum cordifolium*, *Sonerila* sp.,  
*Begonia* spp. (5 species), *Mondopsis petelotii*, *Tainia viridifusca*,  
*Calanthe aleizettii*, *Ophiopogon latifolius*, *Tupistra albiflora*,  
*C. densiflora*, *Ophiopogon* sp., *Vrydagzynea albida*,  
*C. herbacea*, *Ophiorrhiza baviensis*, *Zeuxine nervosa*,  
*C. lyroglossa*, *Ophiorrhiza* spp. (2-3 species), *Zingiber* sp.

Ferns and fern allies:

*Bolbitis* sp., *Diplazium* sp., *Microlepia hookeriana*,  
*Cyclosorus* sp., *Hemigramma decurrens*, *Pleocnemia leuzeana*,  
*Diplazium donianum*, *Lindsaea javanensis*,

The most common projective coverage of this forest stratum varies from (10–) 25 to 70%.

**6th forest stratum (mosses and lichens).** Few to many species of bryophytes less than 2 cm tall, mainly on decaying timber in shady places with projective coverage under than 2%.

**Non-strata vegetation. Epiphytes and semi-epiphytes.** Among the common species which form regular component of epiphytic plant communities in the forest of this type were observed typical epiphytic ferns *Asplenium nidus*, *Aglaomorpha coronans*, *Davallia divaricata*, *Pyrrosia* spp. (2 species), orchids – *Eria thao*, *Callostylis rigida*, *Epigeneium amplum* and creeping epiphytic lianas – *Aeschynanthus* spp. (2 species), *Medinilla alternifolia*, *Pothos* sp., *Psychotria serpens*

and *Rhaphidophora decursiva*.

A great number of associated species were found in epiphytic communities of broad-leaved submontane forests. Among them are numerous epiphytic mosses (representatives of Bryopsida that are particularly common at base of tree boles, on canopy branches and leaves, especially in shady places), ferns, orchids, and creeping epiphyte vines. Species most commonly observed here were:

Orchids (Orchidaceae):

<i>Appendicula</i> sp.,	<i>D. nobile</i> ,	<i>E. thao</i> ,
<i>Bulbophyllum affine</i> ,	<i>Dendrobium</i> spp. (2-3 sp.),	<i>Flickingeria</i> sp.,
<i>B. insulsum</i> ,	<i>Epigeneium chapaense</i> ,	<i>Liparis chapaense</i> ,
<i>Bulbophyllum</i> spp. (3 species),	<i>Eria amica</i> ,	<i>Pholidota chinensis</i> ,
<i>Callostylis rigida</i> ,	<i>E. gagnepaini</i> ,	<i>Schoenorchis gemmata</i> ,
<i>Ceratostylis himalaica</i> ,	<i>E. paniculata</i> ,	<i>Sunipia scariosa</i> ,
<i>Dendrobium acinaciforme</i> ,	<i>E. pannea</i> ,	<i>Trichotosia velutina</i> .
<i>D. chrysanthum</i> ,	<i>E. siamensis</i> ,	

Ferns:

<i>Asplenium ensiforme</i> ,	<i>Elaphoglossum</i> sp.,	<i>Polypodium</i> sp.,
<i>A. wrightii</i> ,	<i>Grammitis</i> sp.,	<i>Vittaria</i> sp.
<i>Colysis digitata</i> ,	<i>Polypodium bourretii</i> ,	

Epiphytic shrubs:

<i>Rhododendron</i> sp.,	<i>Schefflera</i> sp.
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Creeping epiphytic vines:

<i>Aeschynanthus</i> sp.,	<i>Ficus pumila</i> ,	<i>Pothos</i> sp.,
<i>Crepidomanes auriculatum</i> ,	<i>Lepisorus subrostratus</i> ,	<i>Psychotria serpens</i> ,
<i>Davallia divaricata</i> ,	<i>Medinilla alternifolia</i> ,	<i>Rhaphidophora</i> sp.,
<i>D. repens</i> ,	<i>M. pterocaula</i> ,	<i>Scindapsus</i> sp.,
<i>Dischidia</i> sp.,	<i>Piper</i> sp.,	<i>Vaccinium</i> sp.

Woody vines and climbers are common. Among the regular lianas are *Calamus* sp., *Korthalsia* sp., *Smilax* sp., *Stauntonia* sp. and *Tetrastigma* spp. Occasionally observed associated herb and woody vine species in these forests are:

<i>Acacia comosa</i> ,	<i>Embelia pulchella</i> ,	<i>Strychnos</i> sp.,
<i>A. pinnata</i> ,	<i>Entada pursathae</i> ,	<i>Tetrastigma planicaule</i> ,
<i>Aristolochia</i> sp.,	<i>Fibraurea tinctoria</i> ,	<i>Tetrastigma</i> sp.,
<i>Bauhinia touranensis</i> ,	<i>Fissistigma balansae</i> ,	<i>Vanilla annamica</i> ,
<i>Bauhinia</i> spp. (2 species),	<i>Gnetum</i> sp.,	<i>Vernonia sylvatica</i> ,
<i>Caesalpinia</i> sp.,	<i>Paederia</i> sp.,	Annonaceae gen. sp. (3 species),
<i>Callerya cinerea</i> ,	<i>Piper</i> sp.,	Asclepiadaceae gen. sp.
<i>Dalbergia</i> sp.,	<i>Smilax</i> spp. (2 species),	
<i>Dischidia</i> sp.,	<i>Stauntonia</i> sp.,	

Numerous lithophytic species may be seen on rocky outcrops, especially on shady stream and river slopes in broad-leaved submontane forests. Most common lithophytes are numerous shade-loving mosses (including *Polytrichum* species, that

sometimes reach projective coverage on shady rocks up to 100%), ferns – *Asplenium* sp., *Bolbitis* sp., *Leptochilus decurrens*, *Microsorium* sp., *Lepisorus* spp. (3 species), *Colysis digitata*, *C. pothifolia*, *Vittaria forrestiana*, *Vittaria* sp. and herbs – *Ophiopogon latifolius*, *Pilea* sp. and *Tupistra albiflora*.

Among plants of specific living forms in broad-leaved submontane forests were observed the canopy shrub semiparasite – *Loranthus* sp. and small mycotrophic achlorophyllous herbs, *Didymoplexiopsis kiriwongensis* (Orchidaceae) and *Monotropastrum humile* (Ericaceae).

### 1.2.b. Closed evergreen tropical monsoon (seasonal) submontane mixed forests [I.A.2b(1–2)]

**Altitudinal range in the studied area.** 960–1400 m a.s.l.

**Slope inclination and geomorphologic preference.** Commonly 20–40°. Upper parts of mountain slopes.

**Parent soil material.** Granite, quartzite and quartzite sandstone, commonly with numerous large quartzite dikes.

**Leaf litter.** From 4 to 8(–9) cm thick, overlaid by layer of fragments of unidentifiable leaves and twigs 1.5–3 cm thick.

**Soil (depth of layer in cm from the surface).** About 0–20 cm – dark-brown, gray-brown or brown, distinctly friable, rich in humus; 20–40 cm – yellow-brown, sandy-clayey, friable; 40 – 60–70 cm – yellow-orange, clayey, with numerous pieces of quartzite; deeper than 60 – 70 cm yellow, sandy-clayey mineral horizon of residuum and fragments of weathered parent rocks.

**1st forest stratum (tree storey).** Regular co-dominants (occasionally oligo- or mono-dominants) are evergreen broad-leaved trees – *Madhuca pasquieri*, *Lithocarpus* spp. and conifers – *Dacrycarpus imbricatus* and *Fokienia hodginsii*. Elevational range of *Dacrycarpus imbricatus* in the belt of submontane forests in the studied area varies from 700 to 1400 m a.s.l. (Table 2), while *Fokienia hodginsii* was observed as co-dominant in this vegetation belt beginning from 900 m up to 1400 m a.s.l. or higher. Trees of this stratum commonly reach 40–45 m tall and 60–150 cm in diameter. Projective coverage of this stratum varies in the area from 50 to 60%.

Vertical and horizontal structure of other strata in submontane mixed forests, as well as character and species composition of their non strata component are very similar with the previous type of forest (1.2.a).

### 1.2.c. Closed evergreen tropical monsoon (seasonal) submontane coniferous forests [I.A.2b(2)]

**Altitudinal range in the studied area.** (900–)1300 – 1400 m a.s.l.

**Slope inclination and geomorphologic preference.** About 40°. Upper parts of mountain slopes and tops of ridge.

**Parent soil material.** Granite and sandstone, commonly with numerous large quartzite dikes.

**Leaf litter.** From 4 to 7 cm thick, overlaid by layer of fragments of unidentifiable leaves and twigs 2–3 cm thick.

**Soil (depth of layer in cm from the surface).** About 0 – 20(–25 cm) – dark-brown to brown, distinctly friable, rich in humus; 25–25 – 50–55 cm – yellow-brown to yellow, sandy friable; deeper than 50–55 cm – yellow-orange sandy-clayey mineral horizon of residuum and fragments of weathered parent rocks.

**1st forest stratum (tree storey).** Formed by mono-dominant stand of *Fokienia hodginsii*, which commonly reach 40 m high and 90–120 cm in diameter. Projective coverage of this stratum varies in the area from 50 to 60%. *Dacrycarpus imbricatus* may appear as occasional associate in the first forest stratum of these forests at 900–1000 m a.s.l.

Lower strata in these forests are composed of broad-leaved trees. Vertical and horizontal structure of all lower strata in submontane coniferous forests, as well as character and species composition of their non-strata component are very similar to the broad-leaved forest type (1.2.a).

### 1.3. Closed evergreen tropical monsoon (seasonal) lower montane forests [I.A.2c]

Relatively large areas of intact lower montane forests still exist in the southern part of Van Ban District between 1400 and 2200 m a.s.l. As main dominant trees of first forest stratum, species of moderate temperature conditions appear to be common here. On not too steep slopes, especially in low and middle part of mountain slopes main dominants are broad-leaved evergreen and deciduous trees, such as species of *Acer*, *Archidendron*, *Cryptocarya*, *Eberhardtia*, *Exbucklandia*, *Lithocarpus*, *Quercus*, *Litsea*, *Magnolia*, *Manglietia*, *Michelia*, *Rehderodendron*, *Rhoiptelea*, *Schima*, *Symplocos* etc. These trees reach 35–40 m high and form the first stratum of **closed evergreen tropical monsoon (seasonal) lower montane broad-leaved forests**. Along tops of ridges, in upper parts of mountain slopes, especially in dry conditions of more steep slopes in first forest stratum as an important co-dominant appears a conifer – *Fokienia hodginsii*. This tree together with broad-leaved trees forms the **closed evergreen tropical monsoon (seasonal) lower montane mixed forests**. Along relatively dry narrow summits of ridges having very steep slopes *Fokienia hodginsii* regularly is found as mono-dominant of the first forest stratum forming **closed evergreen tropical monsoon (seasonal) lower montane coniferous forests**. The most common tree-associates of the first and second forest strata reach 25–30 m high. In montane forests in the studied area, they are represented by a great number of broad-leaved evergreen and deciduous species (Table 2).

#### 1.3.a. Closed evergreen tropical monsoon (seasonal) lower montane broad-leaved forests [I.A.2c(1)]

**Altitudinal range in the studied area.** 1400–2200 m a.s.l.

**Slope inclination and geomorphologic preference.** About 40°. Middle and

lower parts of mountain slopes.

**Parent soil material.** Granite with numerous large quartzite dikes.

**Leaf litter.** From 5 to 7 cm thick, overlaid by layer of fragments of unidentifiable leaves and twigs 2–3 cm thick.

**Soil (depth of layer in cm from the surface).** 0 – 20 cm – brown, rich in humus; 20 – 40–50 yellow-brown to yellow, sandy-clayey; deeper than 50 cm was not observed.

**1st forest stratum (tree storey).** This stratum is commonly formed by broad-leaved evergreen trees, such as *Exbucklandia populnea*, *Rhodoleia championii* and *Lithocarpus* sp. A deciduous tree *Rehderodendron macrocarpum* (which usually more typical for the second forest stratum) sometimes appears as occasional associate of this stratum. Trees here reach regularly 35–40 m tall and 70–100 cm in diameter. Projective coverage of this stratum varies in the area around 30%.

**2nd forest stratum (tree storey).** As most common trees in this stratum in the studied area are observed evergreen species like *Cryptocarya* sp., *Lithocarpus* sp., *Schima wallichii* and deciduous trees *Rehderodendron macrocarpum* and *Rhoiptelea chiliantha*. Trees of second forest stratum commonly reach 20–30 m high and 30–40 cm in diameter. Projective coverage of this storey is usually about 40%.

**3rd forest stratum (tree storey).** Usually certain domination of any species in this stratum cannot be seen, while forest stands here is represented by numerous evergreen species among which were observed *Anneslea fragrans*, *Litsea* sp., *Symplocos* sp. and *Turpinia montana*. Among deciduous representatives of this stratum most commonly occurs *Acer laurinum*. Trees of this stratum regularly reach 10–15 m tall and 10–20 cm in diameter. Observed projective coverage of their canopies varies from 20 to 25%.

**4th forest stratum (shrubs).** *Arundinaria* sp. and related bamboo species very often appear as co-dominants in forest understory. Among most common shrubby associates, here may be mentioned *Ardisia* sp., *Illicium petelotii*, *Litsea* sp., *Meliosma lepidota*, *Rhododendron cyanocarpum*<sup>4</sup> and *Schefflera* sp. All these species are evergreen shrubs 3–7 m tall. Total projective coverage in this stratum is usually 20–25%.

**5th forest stratum (undershrubs and herbs).** Height of the stratum is under 2 m. Sedges from such genera as *Carex* and *Scleria* are regular co-dominants in herb forest stratum. Other common associates on the forest floor are small shrub and undershrub species from such genera as *Ardisia*, *Lasianthus*, *Pittosporum*, *Turpinia* and *Aucuba japonica*. Numerous herbs and ferns also are very typical for the forest floor in montane broadleaved forests. Among them are such herbs as *Alpinia* sp., *Asarum glabrum*, *Begonia* sp., *Hydrocotyle siamica*, *Lysimachia laxa*, *Ophiopogon* sp., *Paris polyphylla*, *Viola* spp., and terrestrial ferns like *Asplenium normale*, *Polystichum* spp. (2 species), *Tectaria* sp. and *Woodwardia unigemmata*. Observed projective coverage of this stratum rare exceeds 5%.

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<sup>4</sup> Elevation – 1350–1400 m a.s.l. is observed as low limit of distribution of terrestrial shrubby *Rhododendron* species in studied area.

**6th forest stratum (mosses and lichens).** Few species that belong to Bryopsida (including *Polytrichum* sp.) 1–6 cm tall, commonly occur on wet decaying logs in shady places. Projective coverage do not exceeds 1–2%.

**Non-strata vegetation. Epiphytes and semi-epiphytes.** Epiphytic mosses occur abundantly, particularly on tree stems and canopy branches. Other dominants in epiphytic plant communities in these forests are ferns from such genera as *Lepisorus* and *Pyrrosia*. Among co-dominant species, which also commonly occur in broad-leaved montane forests are other species of ferns and orchids. Among them are fern – *Vittaria* sp., orchids – *Bulbophyllum hymenanthum*, *Bulbophyllum* sp., *Coelogyne lockii*, *Cymbidium floribundum*, *Epigeneium chapaense*, *Otochilus* sp., *Pholidota articulata* and creeping epiphytic vines like *Ficus pumila*, *Hedera chinensis* and *Piper* sp. **Climbers and lianas** are not rare. Most commonly recorded species are large woody vines *Acacia* sp., *Celastrus* sp., *Gnetum* sp., *Luvunga scandens*, *Stauntonia* sp., *Tetrastigma planicaule*, *Tetrastigma* sp. and climbing vine shrubs, like different species of *Rubus*. **Lithophytes.** Numerous mosses are common, particularly on rocks in shady wet places with occasional local coverage up to 100% and shade-loving ferns, such as *Colysis elliptica* and *Phymatodes rhynchophylla*.

**Plants of specific life forms.** Among specific living form was regularly observed a white mycotrophic achlorophyllous herb – *Monotropastrum humile*.

### 1.3.b. Closed evergreen tropical monsoon (seasonal) lower montane mixed forests [I.A.2c(1-2)]<sup>5</sup>

**Altitudinal range in the studied area.** 1640–2200 m a.s.l.

**Slope inclination and geomorphologic preference.** Varies from 15 to 40°. Upper parts of mountain slopes (usually of NE exposition) and summits of ridges.

**Parent soil material.** Granite, quartzite, hard highly metamorphosed sandstone with numerous large quartzite dikes.

**Leaf litter.** From 4 to 10 cm thick (up to 30 cm in local depressions), overlaid by layer of fragments of unidentifiable leaves and twigs 2–7 cm thick.

**Soil (depth of layer in cm from the surface).** 0 – 15–40 cm – brown to dark brown, rich in humus; 15–40 – 30–60 cm – gray to gray-brown; 30–60 – 70–110 cm – yellow to yellow-orange sandy-clayey horizon with pieces of weathered parent more or less large rocks and pieces of quartzite. In lower part of slopes are often observed numerous outcropping rocks and boulders.

**1st forest stratum (tree storey).** Regular coniferous co-dominant of this stratum is *Fokienia hodginsii*, which associates with such broad-leaved co-dominants as *Cryptocarya* sp., *Lithocarpus* spp. (2 species), *Litsea* sp., *Magnolia* sp., *Michelia* spp. (2 species), *Rhodoleia championii* and *Schima wallichii*. This group of trees includes some deciduous species, among which most commonly were observed *Acer*

<sup>5</sup> Closed tropical monsoon (seasonal) evergreen montane broad-leaved forest with needle-leaved (coniferous) emergents is included in this vegetation category in this paper.

*laurinum* and *Rehderodendron macrocarpum*. As associated tree species occur *Eberhardtia aurata* and representatives of Sapindaceae. Common height of this stratum is 20–35 m. Trees reach 20–30(35) m tall and (30)40–70 cm in diameter. Usual projective coverage of this stratum is about 40–50%. In mountain slopes near the summits of ridges individuals of *Fokienia hodginsii* sometimes appear as emergents, which tower in matrix of continuous cover of broad-leaved trees. These emergent trees reach 40–50 m high with boles 110–150 cm in diameter. Projective coverage of their canopies is commonly not higher than 15–30%. Another rare coniferous emergent in these forests is *Taiwania cryptomerioides*, which was found in the studied area in highland valleys and on more or less reclined slopes at elevation 2000–2100 m a.s.l. (Nguyen Tien Hiep, Do Tien Doan, Phan Ke Loc, 2002). This rare indigenous tree reaches 30 m tall with boles more than 1 m in diameter. The discovery of *T. cryptomerioides* in the studied area outlines southern border of native distribution of this rare ancient tree, endemic to southern part of Eastern Asiatic floristic region.

**2nd forest stratum (tree storey).** Height of this stratum is (7)15–20(25) m with projective coverage 15–40%. Tree dominants here belong to evergreen species, among which most commonly found are *Cinnamomum* sp., *Lithocarpus* sp. and *Symplocos* sp. with bole diameter 15–40 cm. Regular associates are evergreen species like *Actinodaphne* sp., *Eberhardtia aurata*, *Litsea* sp., *Meliosma lepidota*, *Quercus* sp., *Rhododendron* sp., *Rhoiptelea chiliantha*, *Schefflera* sp. and *Schima wallichii*. An occasional deciduous tree in this stratum is *Acer laurinum*.

**3rd forest stratum (tree storey).** This stratum is not always clear pronounced. However, in some places its projective coverage may reach 40–50%. Trees here have commonly height 7–10 m tall with boles 10–15 cm in diameter. Most common species in this stratum are evergreen trees – *Illicium petelotii*, *Myrsine* sp., *Rhododendron cyanocarpum* and *Rhododendron* sp. In addition, juvenile samples of *Fokienia hodginsii* occur, as well as deciduous small trees *Acer laurinum* and *Enkianthus* sp.

**4th forest stratum (shrubs).** The stratum is usually clear pronounced and is formed exclusively by evergreen shrubby species. Height is 3–6(7) m with projective coverage up to 90%. Regular co-dominants are *Illicium petelotii* and middle tall bamboo species. Numerous associates include *Actinodaphne pilosa*, *Actinodaphne* sp., *Aglaiia* sp., *Aidia* sp., *Ardisia* spp. (2 species), *Carallia lucida*, *Ilex* sp., *Lasianthus* spp. (3 species), *Litsea* sp., *Meliosma lepidota*, *Myrsine* sp., *Oxysspora* sp., *Paralbizia* sp., *Phyllanthus* sp., *Podocarpus neriifolius*, *Rhododendron cyanocarpum*, *Rhododendron* spp. (2 species) and *Schefflera* sp., as well as a number of juvenile unidentifiable samples from Annonaceae, Euphorbiaceae, Lauraceae and Rubiaceae families.

**5th forest stratum (undershrubs and herbs).** The stratum includes shrubs, undershrubs, grasses, sedges and herbs up to 3 m tall. Projective coverage of this stratum varies from 2–3 to 60%. Among the most common shrubby species were observed *Allomorpha* sp., *Lasianthus* sp., *Phyllagathis* sp., as well as *Arundinaria* sp. and other related bamboo species. Co-dominant herbs and ferns in this stratum are *Begonia* sp., *Diplazium maximum*, *Pilea* spp. (2 species), *Polystichum* spp. (2 species), *Pteris* sp., *Rumohra diffracta* and *Selaginella* sp. Occasional shrub species occurring



here include such associates as *Ardisia* spp. (2 species), *Croton* sp., *Fordiophyton strictum*, *Mycetia balansae*, *Oxyspora* sp., *Phyllanthus* sp., *Smilax* sp., *Tarenna* sp., many representatives of Rubiaceae, juvenile samples of *Calamus* sp. and seedlings of *Fokienia hodginsii*. Occasional herbs, sedges, ferns and their allies are *Alpinia* sp., *Anoectochilus roxburghii*, *Arisaema* sp., *Asplenium normale*, *Calanthe herba-cea*, *Carex* spp. (2 species), *Cephalantheropsis obcordata*, *Cymbidium ensifolium*, *Dianella nemorosa*, *Diplasium donianum*, *Disporum* sp., *Huperzia serrata*, *Ophiopogon* sp., *Ophiorrhiza baviensis*, *Paris polyphylla*, *Peliosanthes teta*, *Peliosanthes* sp., *Piper* spp. (2 species), *Plagiogyria* sp., *Polystichum* sp., *Scleria* sp., *Selaginella* sp. and *Stegnogramme scalani*.

**6th forest stratum (mosses and lichens).** Cover of this stratum is found occasionally in more wet shady places and usually less than 1%. It is formed by few species of mosses from Bryopsida and Marchantiopsida 1–2 cm tall. They occasionally form continuous blanket with local coverage up to 100% on large roots, decaying logs and on large shady rocks.

**Non-strata vegetation. Epiphytes and semi-epiphytes.** Epiphytic communities in canopies of trees of first and second forest stratum are well pronounced and represented by numerous species of orchids, ferns and ericaceous plants. Among them most common are *Bulbophyllum* spp. (2 species), *Ceratostylis himalaica*, *Coelogyne lockii*, *Coelogyne* sp., *Pholidota articulata*, *Pyrrosia* sp., *Rhododendron* spp. (2 species) and *Vaccinium* spp. (2 species). Very common here are numerous species of Bryopsida with pendent shoots up to 15–20 cm long. Occasional associates in epiphytic communities of these forests were observed many other species of orchids (*Bulbophyllum reptans*, *Bulbophyllum* sp., *Ceratostylis pygmaea*, *Epigeneium chapaense*, *Otochilus* sp., *Panisea tricallosa*) and ferns (*Asplenium ensiforme*, *A. prolongatum*, *Davallia divaricata*, *D. repens*, *Polypodium amplexicaule*, *Pyrrosia* sp., *Scleroglossum minus*, *Vittaria* sp.). Numerous epiphytic creeping vines are typical in forest of this type. Among them are very common *Aeschynanthus* spp. (2 species), *Hoya* sp., *Hymenophyllum* sp., *Medinilla pterocaula*, *Piper* sp., *Pyrrosia* sp., *Scindapsus* sp. and *Vaccinium* spp. (2 species). **Climbers and lianas** are common. They are represented by herbs and suffrutescent vines, like *Crawfordia* sp., *Embelia polypodioides*, *Jasminum* sp., *Piper* sp., *Rubus* sp., *Smilax* spp. (2 species), *Stauntonia* sp., some species of Rubiaceae, as well as large woody lianas which may reach 20–35 m long (*Celastrus* sp., *Dalbergia* sp., *Embelia pulchella*, *Korthalsia* sp., *Tetrastigma planicaule*, *Tetrastigma* sp., representatives of Annonaceae and Menispermaceae). Lithophytic vegetation is observed in studied forests of this type on rocky slopes and in places of rocky outcrops. As common lithophytic undershrubs, here appear species of *Ardisia* and *Strobilanthes*, as well as woody fern *Cyathea podophylla*. Many species of different flowering plant families, as well as ferns and their allies are found here as herbaceous lithophytes. The most common among them are:

<i>Aeschynanthus</i> sp.,	<i>Arisaema</i> spp. (3 species),	<i>Diglyphosa evrardii</i> ,
<i>Anoectochilus elvesii</i> ,	<i>Begonia</i> spp. (2 species),	<i>Egenolfia</i> sp.,
<i>A. roxburghii</i> ,	<i>Colysis</i> sp.,	<i>Goodyera foliosa</i> ,

<i>G. viridiflora</i> ,	<i>Pilea</i> spp. (3 species),	<i>Rhomboda petelotii</i> ,
<i>Lepisorus</i> spp. (2 species),	<i>Polypodium amplexicaule</i> ,	<i>Rumohra diffracta</i> ,
<i>Leptochilus decurrens</i> ,	<i>Polystichum</i> spp. (2 species),	<i>Selaginella</i> sp.,
<i>Ophiorrhiza baviensis</i> ,	<i>Primula</i> sp.,	<i>Trichomanes</i> sp.
<i>Ophiorrhiza</i> sp.,	<i>Pteris</i> sp.,	

A number of common lithophytic species in such habitats belong to Acanthaceae and Gesneriaceae. In more or less shady humid conditions, lithophytic mosses may reach coverage 100% in ground stratum.

Among plants of specific life forms were occasionally observed large achlorophyllous orchid vine – *Galeola nudiflora* and dwarf white mycotrophic herb – *Monotropastrum humile*.

### 1.3.c. Closed evergreen tropical monsoon (seasonal) lower montane coniferous forests [I.A.2c(2)]

**Altitudinal range in the studied area.** 1460–2100 m a.s.l.

**Slope inclination and geomorphologic preference.** Varies from 0 to 60°. Upper parts of ridges slopes of any exposition, but particularly tops and summits of ridges.

**Parent soil material.** Granite, quartzite, hard highly metamorphosed sandstone with numerous large quartzite dikes.

**Leaf litter.** Commonly from 4 to 7 cm thick, overlaid by layer of fragments of unidentifiable leaves and twigs 2–3 cm thick.

**Soil (depth of layer in cm from the surface).** 0 – 15–30 cm – dark brown to brown, rich in humus; 15–30 – 35–70 cm – yellow-brown to yellow, sandy; (30–) 40–60 (–70) – 100–200 cm – yellow to yellow-orange (or occasionally yellow-brown) based on sandy-clayey mineral horizon of weathered parent rocks with more or less large pieces of sandstone and quartzite.

**1st forest stratum (tree storey).** Regularly first stratum of coniferous mountain forests in the study area is comprised of mono-dominant stands of *Fokienia hodginsii*. This giant cypress 40–50 m in height with bole diameter of 80–120 (–150) cm forms majestic pristine forests with projective coverage (40) 60–80%. Mature trees in these stands may be 1500–2000 years old. These forests represent one of the most endangered types of vegetation in the world. Occasional associates of the first stratum in coniferous forests are evergreen broad-leaved trees, such as *Lithocarpus* spp. (2 species) and *Rhodoleia championii*.

**2nd forest stratum (tree storey).** Evergreen co-dominants of this stratum are *Cryptocarya* sp., *Eberhardtia aurata*, *Exbucklandia populnea*, *Lithocarpus* sp., *Manglietia* sp., *Michelia* sp. *Rhodoleia championii* and *Schima wallichii*. Deciduous component of co-dominants include *Rehderodendron macrocarpum* and *Rhoiptelea chiliantha*. Trees of this stratum have height of (18–) 20–30 (–35) m and diameter of 30–50 (–70) cm.

**3rd forest stratum (tree storey).** Occasionally *Rhododendron basilicum* was observed as mono-dominant evergreen species in this stratum. However, commonly the stratum is represented by numerous associated evergreen and deciduous tree species that exhibit no certain dominance. Among them are evergreen trees, such as *Archidendron balansae*, *Cryptocarya* sp., *Elaeocarpus tonkinensis*, *Litsea* sp., *Meliosma lepidota*, *Podocarpus neriifolius*, *Randia* sp., *Rhododendron cyanocarpum*, *Schefflera* sp., and deciduous tree species *Acer laurinum*, *Acer* sp., *Carpinus* sp., *Rhoiptelea chiliantha* and *Sorbus* sp. Here also may be seen some species of Anacardiaceae and Sapindaceae. Common height of this stratum is 7–15 (–20) m with boles (10–) 15–25 cm in diameter. Projective coverage lies between 25 to 45%.

**4th forest stratum (shrubs).** Numerous evergreen species of shrubs and small trees 3–7 m tall form this stratum with usual projective coverage 20–60%. The most common co-dominant species here are *Illicium petelotii*, *I. tsaii*, *Rhododendron cyanocarpum*, *Rhododendron* spp. (5–8 species) along with such more or less common associates such as *Actinodaphne pilosa*, *Actinodaphne* sp., *Ardisia* sp., *Canthium* sp., *Carallia lucida*, *Lasianthus* spp. (2 species), *Litsea* sp., *Macaranga* sp., *Meliosma lepidota*, *Myrsine* sp., *Oxyspora* sp., *Randia* sp., *Schefflera* sp., saplings of *Cinnamomum* sp., *Ilex* sp., *Podocarpus neriifolius*, some species of *Rubiaceae* and woody fern *Cyathea podophylla*.

**5th forest stratum (undershrubs and herbs).** Height of this stratum commonly does not exceed 2–3 m. Its projective coverage may be only 5–10%, but usually varies between 30 and 60%. Among shrubs and undershrubs are commonly found such species as *Ardisia* spp. (2–3 species), *Croton* sp., *Lasianthus* sp., *Melicope pteleifolia*, *Oxyspora* sp., *Phyllagathis* sp., *Polygala* sp., *Rhododendron cinnabarium*, *Rh. ramsdenianum*, *Rh. wallichii*, *Smilax* sp., some species of *Rubiaceae*, juvenile samples of *Calamus* sp. and *Pandanus* sp., as well as *Arundinaria* sp. and related genera of dwarf bamboo. Most common ferns, sedges and herbs here are *Arachniodes* sp., *Asplenium normale*, *Begonia* sp., *Carex* sp., *Coryphopteris hirsutipes*, *Polystichum* spp. (2–3 species), *Scleria* sp. and *Sonerila* spp. (2 species). Among their associates were observed *Ainsliaea* spp. (2 species), *Alpinia* sp., *Anoectochilus roxburghii*, *Asplenium* sp., *Carex baccans*, *Curculigo* sp., *Ophiopogon* sp., *Osmunda banksiaefolia*, *Peliosanthes teta*, *Peliosanthes* sp., *Phyllanthus* sp., *Piper* sp., *Plagiogyria stenocarpa*, *P. yunnanensis*, *Polygala* sp., *Polystichum* sp., *Scleria* sp., *Selaginella* sp. (2 species), *Stegnogramme griffithii*, *Woodwardia unigemmata*, some species of *Gesneriaceae*, *Melastomataceae* and numerous tree seedlings.

**6th forest stratum (mosses and lichens).** Commonly projective coverage of this stratum less than 1% and consist of species of *Bryopsida* and *Marchantiopsida* 0.5–3 cm tall growing only on large roots and decaying wood. However, in other places moss cover may reach 10–15% of ground. In such conditions occur many species of *Bryopsida*, among which most usual species of *Polytrichum*.

**Non-strata vegetation. Epiphytes and semi-epiphytes.** Epiphytes are abundant. Among the most common are ferns (*Asplenium ensifolia*, *A. nidus*, *A. prolongatum*, *Davallia repens*, *Hymenophyllum* sp., *Lepisorus* sp., *Oleandra musci-*

*folia*, *Pyrrosia* sp., *Trichomanes* sp.), orchids (*Epigeneium chapaense*, *Coelogyne* sp., *Pholidota articulata*) and ericaceous tuberiferous shrubby and vine species of *Vaccinium* and *Rhododendron*. Occasionally observed epiphytic species in this type of forest are:

<i>Aeschynanthus</i> spp. (2 species),	<i>Coelogyne</i> sp.,	<i>Otochilus</i> sp.,
<i>Bulbophyllum emarginatum</i> ,	<i>Cymbidium floribundum</i> ,	<i>Panisea tricallosa</i> ,
<i>B. reptans</i> ,	<i>Dendrobium longicornu</i> ,	<i>Pholidota chinensis</i> ,
<i>Bulbophyllum</i> spp. (2 species),	<i>Dendrobium</i> sp.,	<i>Phymatodes</i> sp.,
<i>Callostylis rigida</i> ,	<i>Elaphoglossum</i> sp.,	<i>Polypodium</i> sp.,
<i>Coelogyne lockii</i> ,	<i>Hoya</i> sp.,	<i>Vittaria</i> sp.

Moss species play considerable role in epiphytic communities with projected coverage that often reaches 100% on tree stems and roots, particularly near the ground.

**Climbers and lianas.** Small herb and suffrutescent vines, such as *Smilax* spp. (2 species) and *Stauntonia* sp. may be very common, but other vine species were observed only as occasional associates. Among these species were found *Acacia* sp., *Alyxia* sp., *Calamus* sp., *Dalbergia* sp., *Embelia polypodioides*, *E. pulchella*, *Kadsura coccinea*, *Korthalsia* sp., *Milium* sp. and some species of Rubiaceae. Some creeping epiphytic lianas (for example, *Medinilla pterocaula*, *Piper* sp., *Vaccinium* sp.) are also typical for these habitats, but large woody climbers here rather rare. **Lithophytes.** Among lithophytes commonly occur species of *Begonia*, Acanthaceae and numerous moss species, particularly from Bryopsida. Moss cover on rocks and boulders may often reach 100% of coverage, especially in shady places with more humid conditions.

**Plants of specific life forms.** In shady forest floor were often observed as a rather common species, mycotrophic achlorophyllous herbs – *Monotropastrum humile*, *Petrosavia sinii*, and ground root parasite *Rhopalocnemis phalloides*. Occasional semiparasitic liana up to 12 m long from Santalaceae family was observed in similar conditions.

#### 1.4. Closed evergreen tropical monsoon (seasonal) upper montane forests [I.A.2c]

##### 1.4.a. Closed evergreen tropical monsoon (seasonal) upper montane broad-leaved forests [I.A.2c(1)]

**Altitudinal range in the studied area.** 2200–2640 m a.s.l.

**Slope inclination and geomorphologic preference.** Varies in the studied area from 0 to 50°. Mountain tops of ridges of different direction, steep ridge slopes of any exposition in their upper part approximate to the mountain summits.

**Parent soil material.** Granite, quartzite, hard highly metamorphosed quartzite sandstone with numerous large quartzite dikes.

**Leaf litter.** Varies from (3–) 4–10 (–12) cm thick, overlaid by layer of fragments of unidentifiable leaves and twigs 1–3 cm thick.

**Soil (depth of layer in cm from the surface).** 0–(15)20–40(–60) cm – dark brown to brown, sometimes coming into black-brown to gray-brown in lower portion, rich in humus, often turfy, commonly very rich in rough quartzite sand. Soil with this horizon structure is often placed directly on mother parent rocks. In other cases on depth (30–)40–60 cm is observed horizon of gray to yellow-gray, sandy substrate, which is overlaid by yellow sandy-clayey mineral horizon with numerous fragments of weathered parent rocks and more or less large pieces of quartzite. Horizon of this structure commonly covers parent rocks on not too steep slopes or in small local depressions.

**1st forest stratum (tree storey).** First stratum of these forests includes in the studied area exclusively broad-leaved species<sup>6</sup>. On more or less gentle slopes, in leveled local depressions or small valleys between ridge peaks, forest stands of this type may reach 25–30 m tall with tree boles 40–70 cm in diameter. Main dominants of such forest stands are broad-leaved *Lithocarpus* spp. (2 species), *Michelia* sp., *Rhodoleia championii*, *Schima wallichii* and deciduous *Acer laurinum*. Projective coverage of this stratum is commonly about 50–70%.

**2nd forest stratum (tree storey).** As main co-dominants of this stratum commonly observed are evergreen species of *Rhododendron*, such as *Rhododendron basilicum*, *R. cyanocarpum*, *R. ramsdenianum*, *Rhododendron* spp. (2 species), *Michelia* sp. and deciduous *Rehderodendron macrocarpum* and *Sorbus* sp. that are 10–18 m tall with boles 20–30 cm in diameter. Projective coverage of this stratum is about 30%.

**3rd forest stratum (shrubs).** Height of this stratum is 4–7 m with common projective coverage of about 10%. Most common species here are *Litsea* sp., *Rhododendron ramsdenianum*, *Rhododendron* spp. (2 species), *Symplocos* sp. and deciduous *Enkianthus* sp.

**4th forest stratum (undershrubs and herbs).** Projective coverage of this stratum may reach 25–30(50)%. Height of plants here is under 3 m tall. Most common co-dominants are dwarf bamboo, such as *Arundinaria* sp., as well as *Ardisia* sp., some species of Euphorbiaceae and sedges (*Scleria* sp.). Associated undershrubs are *Polygala* sp., *Rhododendron cinnabarium*, and *R. wallichii*. Among herbs and ferns were occasionally observed *Ainsliaea* spp. (2 species), *Goodyera schlechtendaliana*, *Pedicularis* sp. and *Polystichum* sp. Seedlings and saplings of *Enkianthus* sp., *Schefflera* sp. and some other woody species are also commonly present in this stratum.

**5th forest stratum (mosses and lichens).** Projective moss coverage 1–2 cm tall may reach on ground 4–6%. Among dominant species, there are few

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<sup>6</sup> Highest elevation limits in distribution of *Fokienia hodginsii* are observed in studied area at elevation about 2200 m a.s.l. At this elevation, *Fokienia* samples occur as occasional rather rare emergents in matrix of closed continuous canopy cover of lowest broad-leaved trees. This species was not observed in the area at highest elevation giving way to broad-leaved forests.

representatives of Bryopsida, particularly *Polytrichum* spp.

**Non-strata vegetation. Epiphytes and semi-epiphytes.** Among epiphytes dominate lichens, mosses and ferns. Lichens and mosses are very common, especially on tree boles near the ground and on canopy branches where they often form coverage up to 100%. Most common fern species in epiphytic communities here are *Hymenophyllum* sp., *Oleandra musifolia*, *Trichomanes* sp., with associated species, such as *Elaphoglossum* sp., *Lepisorus* sp., *Phymatodes* sp., *Polypodium* sp., *Pyrrosia* sp. and *Vittaria* sp. Ericaceous epiphytic shrubs and epiphytic creeping vines (*Rhododendron* sp. and *Vaccinium* spp.) are also very common, while orchids become rare. Among orchids here occasionally were observed very few species, such as *Bulbophyllum reptans*, *Coelogyne* sp. and *Dendrobium* sp.<sup>7</sup> A not so rare flowering plant epiphyte, *Polygonatum punctatum*, was found in this forest. **Climbers and lianas.** Climbers are rather rare, among occasionally observed species are small suffrutescent vines like *Embelia polypodioides* and *Smilax* sp.

**Plants of specific life forms.** Dwarf mycotrophic achlorophyllous herbs – *Monotropastrum humile* and *Petrosavia sinii*, as well as canopy parasitic shrubs *Loranthus* sp. and *Viscum articulatum* are occasionally common.

On very steep slopes, along narrow ridges and on mountain tops tall forest stands give way to undersized dwarf cloud mountain forest<sup>8</sup>.

First forest stratum is represented here by gnarled trees 4–6 m tall with boles 20–35 cm in diameter. Aside from already mentioned species (*Lithocarpus* spp., *Michelia* sp., *Rhodoleia championii*, *Schima wallichii*, *Acer laurinum*) in first stratum of such forests appear numerous species of Ericaceae – *Rhododendron basilicum*, *R. cyanocarpum*, *R. ramsdenianum*, *Rhododendron* spp. (2 species), *Pieris* sp., as well as *Illicium tsaii* and *Symplocos* sp. Among deciduous trees, here are very common species of temperate genera, such as *Enkianthus*, *Sorbus* and *Acer*. Projective coverage of this stratum ranges from 50 to 80%.

Forest understory is represented by small trees and gnarled treelets about 3–4(–5) m tall. They form total projective coverage 40–60(–70)% and include numerous evergreen and deciduous rhododendrons – *Rhododendron cinnabarium*, *Rh. ramsdenianum*, *Rh. wallichii*, *Rhododendron* spp. (2–3 species), *Daphne* sp., *Ilex* sp., *Linocera* sp., *Myrsine* sp., *Schefflera* sp., *Vaccinium dunalianum*, some species of Lauraceae, deciduous *Pieris* sp., *Vaccinium* sp. and dwarf bamboo (*Arundinaria* sp.), which often form very dense thickets.

Herb stratum is usually less than 1 m tall with usual projective coverage of only 5–10%. It includes such ferns, herbs and undershrubs as *Ainsliaea* spp. (2 species),

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<sup>7</sup> Basically most epiphytic orchids in studied area have elevation limits at 2200–2250 m a.s.l. and were not observed at higher elevation, where lichens, mosses, ferns and species of Ericaceae appear as a regular co-dominants in epiphytic communities.

<sup>8</sup> These low, wind formed broad-leaved montane forests that are observed on high mountain tops in studied area may be interpreted as azonal derivatives of closed evergreen tropical monsoon (seasonal) montane broad-leaved forests – I.A.2c(1).

*Dryopteris* sp., *Goodyera schlechtendaliana*, *Ophiopogon* spp. (2 species), *Pedicularis* sp., *Plagiogyria yunnanensis*, *Polygala* sp., *Polystichum* sp. and *Smilax* sp.

Ground stratum in forests of this type includes lichens (many species, mainly *Cladonia*), mosses (many species, including *Polytrichum* spp. and *Sphagnum* spp.) and dwarf moss-like ferns – *Hymenophyllum* sp. and *Trichomanes* spp. (2 species). This stratum has height of under 3(–5) cm and projective coverage from 1 to 50%.

Epiphytic mosses and lichens are likewise abundant. They commonly cover tree stems and branches with continuous massive cover drooping partially up to 10–15 cm from along horizontal branches. Other common epiphytes in this forest are ferns, particularly such species as *Elaphoglossum* sp., *Grammitis* sp., *Hymenophyllum* sp., *Lepisorus* sp., *Phymatodes* sp., *Pyrrosia* sp. and *Trichomanes* spp. (2 species). Angiosperm epiphytes are rare. Among them here were observed *Polygonatum punctatum* and few ericaceous species (mainly *Rhododendron* and *Vaccinium*). Climbers and lianas include small herbaceous and frutescent vines like *Ampelopsis* sp., *Crawfordia* sp., *Rubus* sp. and *Smilax* sp. Creeping lithophytic vine species of *Vaccinium* commonly cover open rock outcrops and cliffs. On tree tops were occasionally observed parasitic shrubs, which belong to Loranthaceae (*Loranthus* sp.), Santalaceae and Viscaceae (*Viscum articulatum*).

### **Azonal types of vegetation**

The most common and important types of azonal vegetation in the studied area are plant communities on open rocky cliffs and riparian plant communities that may be seen along rocky streams and along lower part of stream canyons. All these vegetation types represent specific derivatives of zonal primary montane and sub-montane forests. At the same time, these habitats accumulate and support very high level of plant species diversity, especially rich in rare lithophytic species that rarely occur under shady canopies of primary forest.

### **Lithophytic plant communities on open granite cliffs**

Lithophytic plant communities may be observed along all altitudinal range of the studied area. However, they represent a critically endangered type of vegetation easily destroyed by forest fire or desertification connected with logging of the forest. Under the pressure of these factors, lithophytic communities rapidly lose major parts of primary elements, regeneration of which is very questionable.

The described primary lithophytic communities on exposed rocky granite and quartzite outcrops and cliffs lie in zone of closed evergreen tropical monsoon (seasonal) lower and upper montane broad-leaved, mixed and coniferous forests and represent their derivative. These communities are probably most typical for pristine nature of the studied region at elevation (1700–)1800–2300 m a.s.l.

Cliff inclination in studied habitats ranged from 70 to 80° that provide probably most optimal condition for formation of typical lithophytic cliff plant communities. Leaf litter

and very thin soil accumulated here only in cliff crevices, narrow shelves, and occasional small pockets in bluffy rocks composed in the studied area commonly with granite having numerous large quartzite dikes. Soils here, when present, are hardly developed, gray-black or gray-brown, sandy, based on rough quartzite sand deposits accumulated in pockets and occasional depressions of parent rocks. Under moss pillowy cover are commonly observed 1–3 cm turf deposits.

In the first stratum on granite cliffs occasionally may be seen some trees and shrubs 3–10 m tall that form sometimes projective coverage up to 30–40%. Among most common woody species observed here are evergreen *Ficus subincisa*, *Rhododendron cyanocarpum*, *Rhododendron* sp., *Schefflera* spp. (2 species) and *Tetrapanax papyrifera*. Deciduous trees and shrubs, such as *Acer laurinum*, *Rehderodendron macrocarpum*, *Rhoiptelea chiliantha* and *Sorbus* sp. represent considerable portion in these stratum. In more steep part of slopes this stratum may be absent.

Herb and undershrub stratum is represented by genuine lithophytic species usually 10–150 cm tall. Commonly projective coverage of this stratum 20–40%, but on very steep cliffs and vertical rocks cover may be less than 10%. Among regular dominants here were observed *Carex* sp., *Selaginella* sp., *Panicum bisulcatum* and other grasses including dwarf bamboo (*Arundinaria* sp.). Most usual shrubby associates are *Hypericum hookerianum*, *Polygala* sp., *Rhododendron cinnabarium*, *R. ramsdenianum*, *Rhododendron* spp. (2 species), *Sporoxeia* sp., *Vaccinium dunalianum*, *Vaccinium* spp. (2 species). Herbs and ferns are various, including the following species:

<i>Ainsliaea</i> spp. (2 species),	<i>Elaphoglossum</i> sp.,	<i>Phymatosorus</i> sp.,
<i>Alpinia</i> sp.,	<i>Gentiana</i> sp.,	<i>Pleione grandiflora</i> ,
<i>Asplenium normale</i> ,	<i>Goodyera schlechtendaliana</i> ,	<i>Polypodium</i> spp. (2 species),
<i>Coelogyne lockii</i> ,	<i>Lepisorus macrocarpus</i> ,	<i>Polystichum</i> spp. (2 species),
<i>Coelogyne</i> sp.,	<i>Lepisorus</i> spp. (2 species),	<i>Scleria</i> sp.,
<i>Curculigo</i> sp.,	<i>Oreocharis aurea</i> ,	<i>Sonerila</i> sp.,
<i>Cymbidium floribundum</i> ,	<i>Pholidota articulata</i> ,	<i>Vittaria forrestiana</i> .
<i>Dendrobium</i> sp.,	<i>Phymatodes rhynchophyllus</i> ,	

In open places particularly on south-facing cliffs, creeping xerophytic ferns and lycopodiums become common. Among them are *Dicranopteris linearis*, *D. splendida*, *Dicranopteris* sp., *Lycopodium casuarinoides*, *L. clavatum*, *L. complanatum* and *Pyrrosia* sp.

Ground stratum includes numerous species of lichens (particularly numerous species of *Cladonia*), mosses (particularly species of *Polytrichum* and *Sphagnum*), as well as some dwarf lithophytic ferns and their allies like *Cheilanthes* sp., *Huperzia serrata* and *Scleroglossum* sp. On sunny dry vertical cliffs may be commonly seen dense pillows of *Sedum vietnamense* settled in small rocky crevices. Height of this stratum is 1–5 cm tall. It may reach coverage on ground 40–60% of total surface.

Epiphytes in cliff shrubby communities are very common and often abundant. They include numerous species of lichens, mosses, ferns, and orchids. Commonly observed epiphytic species include *Bulbophyllum emarginatum*, *B. reptans*, *Bulbo-*



*phyllum* spp. (2 species), *Coelogyne lockii*, *Coelogyne* sp., *Cymbidium floribundum*, *Dendrobium longicornu*, *Dendrobium* sp., *Epigeneium chapaense*, *Eria coronaria*, *E. siamensis*, *Otochilus* sp., *Pholidota articulata*, *Vittaria* sp., as well as creeping epiphytic vines *Hoya* sp., *Polypodium* sp. and *Pyrrosia* spp. (2 species). Epiphytic lichens and mosses often completely cover branches of small gnarled trees and shrubs with pendant limbs up to 15–20 cm.

Climbers, lianas and climbing shrubs are numerous and diverse. Among the most common found species are *Albizia* sp., *Celastrus* sp., *Gnetum* sp., *Hedera chinensis*, *Jasminum* sp., *Luvunga scandens*, *Rubus alcaeafolius*, *Rubus* sp., *Smilax* sp., *Stauntonia* sp., *Tetrastigma* sp. and some species of Rubiaceae. Some of these species form on vertical cliffs dense spiny impassable thickets.

Among plants of specific life forms are remarkable annual ephemeral species, which settle in *Sphagnum* pillows and develop a new generation during rainy season when substrates are constantly filled with water. Among such plants were observed species of *Eleocharis* sp. and *Utricularia* sp. Some perennial ephemeroïd herbs occurring here also belong to this ecological group. Among them are undescribed species of *Begonia* with spherical underground tubers and pseudobulbous orchids, such as *Pleione grandiflora*, large colonies of which were found in the studied area (Averyanov et al., 2002; Averyanov, Phan Ke Loc, 2002). Canopy parasitic shrubs like *Loranthus* sp. and *Viscum articulatum* are rather regular component of shrubby lithophytic communities all over the studied area.

### **Riparian plant communities along rocky mountain stream and lower part of stream canyons**

The most rich and typical primary riparian plant communities in the studied area were found and described in mountain belt at elevation 600–1000 m a.s.l., where they represent derivative of closed evergreen tropical monsoon submontane broad-leaved and mixed forests – I.A.2b(1); I.A.2b(1–2). Riparian communities spread along small mountain rivers in humid, more or less shady deep rocky stream valleys, canyons and waterfalls. These habitats support very high level of plant diversity including numerous tree, shrub and herb humid-loving species. Commonly these azonal communities accumulate all plant diversity of surrounding parent forest.

The inclination of river valleys in the studied area averages between 5–10°. The bottom of streambed is composed with rocks and large boulders. Bluffy outcrops of parent rocks commonly appear on lower part of steep river slopes, on sides of narrow stream canyons and on waterfall cliffs. Granite with large quartzite dikes and occasionally pure white quartzite are usual parent rocks in the studied area observed along mountain streams. Alluvial deposits of rough quartzite sands are very common along bottom of river valleys, particularly in more flat places, where they may reach 1 m in depth. Leaf litter on river slopes reaches usually 4–6 cm in thick. It is overlaid by 1–3 cm layer of unidentified decomposed fragments of leaves and twigs. Soils in lower part of river slopes include dark gray- or black-brown, sandy, very friable, upper horizon

20–30 cm in thick rich in humus. On depth of 30–50 cm gray sand is commonly observed. Deep down may be seen yellow sand with soft concretions of weathered rocks overlaid by residuum derived from parent rocks.

In first forest stratum in riparian plant communities in the studied area may be commonly seen evergreen trees, such as *Castanopsis* sp., *Dacrycarpus imbricatus*, *Hopea mollissima*, *Lithocarpus* sp. and *Michelia* sp. They are main dominants of this stratum, which reach 35–45 m tall and 60–100 cm in diameter with projective coverage 50–60%.

Trees of second forest stratum usually reach 18–25(–30) m high with diameter of boles ranging between 20–35 cm. Projective coverage of their canopies about 45–50%. Evergreen species dominate here. Among them most common are *Cinnamomum* sp., *Dillenia* sp., *Dysoxylum* sp., *Elaeocarpus tonkinensis*, *Elaeocarpus* sp., *Gironniera subaequalis*, *Lithocarpus* sp., *Macaranga* sp., *Platea latifolia*, *Chisocheton* sp., *Syzygium* sp. and some representatives of Sapindaceae. *Choerospondias axillaris* is alone deciduous tree typical for this stratum.

Third forest stratum commonly is well pronounced. It reaches 10–15 m in height with projected coverage 30–40%. Very common here are stands of *Dendrocalamus* sp., *Schizostachyum dullooa* and other related species of woody bamboo. Trees of this stratum have commonly boles 10–18 cm in diameter. All tree species are evergreen. Most commonly observed species are *Aglaia* sp., *Anneslea fragrans*, *Cryptocarya* sp., *Dillenia* sp., *Eberhardtia aurata*, *Litsea* sp., *Milium* sp., *Schefflera* sp. and *Turpinia* sp.

Numerous evergreen shrubs form shrub understory in riparian plant communities. The domination of any certain species usually is not observed, but general diversity of shrub species commonly is very high. Among regular species occurring here that may be mentioned are *Aralia chinensis*, *Archidendron balansae*, *Ardisia* sp., *Blastus cochinchinensis*, *Brassaiopsis glomerulata*, *Carallia brachiata*, *Euonymus* sp., *Ficus* spp. (3 species), *Gomphandra* sp., *Lasianthus* spp. (3 species), *Melastoma* sp., *Meliosma lepidota*, *Pseudodissochaeta septentrionalis*, *Sterculia* sp., *Trevesia palmata*, *Turpinia* sp., *Villebrunea integrifolia*, some species of Euphorbiaceae and saplings of *Dacrycarpus imbricatus*. Woody ferns (*Cyathea contaminans*, *C. salettii*, *Cyathea* sp.), dwarf palms and palm-like plants (*Licuala paradoxa*, *Pandanus* sp.) and giant herbs, such as *Amomum* sp. and *Musa* sp. are very typical for these habitats. All mentioned plants form understory stratum 3–7 m tall with usual projective coverage 20–30%.

Undershrubs, ferns and herbs under 2(2.5) m tall form along rivers lush vegetation with projective coverage up to 40–50%. *Blastus cochinchinensis*, *Strobilanthes* spp. (2 species), as well as other representatives of Acanthaceae are usual undershrub dominants on wet river slopes. Here also are commonly found some grasses (*Cyrtococcum* sp.), sedges (*Cyperus* spp., *Fimbristylis* sp., *Kyllinga* spp.), ferns and their allies (*Cyclosorus* sp., *Selaginella* sp., *Tectaria* spp., *Thelypteris* sp.) and creeping moist-loving herbs, such as *Hydrocotyle* spp. (2 species), *Pellionia* spp. (2 species), *Pilea* sp., *Pratia nummularia* and *Viola* spp. (3 species). Among regular shrub asso-

ciates of this stratum were observed *Aralia armata*, *Ardisia* spp. (3 species), *Breynia* sp., *Dracaena* sp., *Ficus* sp., *Lasianthus* spp. (2 species), *Mycetia balansae*, *Pandanus* sp., *Psychotria* sp. and *Schefflera* sp. Herbaceous species composition is very diverse and includes many species of herbs, grasses, sedges, ferns and fern allies. Among commonly observed associates in this group are:

<i>Abacopteris</i> sp.,	<i>Cyrtococcum</i> sp.,	<i>Ophiorrhiza</i> sp.,
<i>Acanthephippium striatum</i> ,	<i>Dianella nemorosa</i> ,	<i>Pentaphragma sinense</i> ,
<i>Aglaonema</i> sp.,	<i>Diplazium donianum</i> ,	<i>Phaius mishmensis</i> ,
<i>Alpinia</i> sp.,	<i>D. maximum</i> ,	<i>Phrynium</i> sp.,
<i>Amomum</i> sp.,	<i>Disporum</i> sp.,	<i>Piper boehmeriaefolium</i> ,
<i>Amorphophallus</i> sp.,	<i>Gonatanthus pumilus</i> ,	<i>Piper</i> sp.,
<i>Angiopteris</i> sp.,	<i>Hapaline</i> aff. <i>colaniae</i> ,	<i>Plectranthus</i> sp.,
<i>Arisaema</i> sp.,	<i>Hedychium</i> sp.,	<i>Polliia</i> sp.,
<i>Aspidistra</i> sp.,	<i>Histiopteris incisa</i> ,	<i>Polygonatum</i> sp.,
<i>Begonia</i> spp. (2 species),	<i>Homalomena occulta</i> ,	<i>Scleria</i> sp.,
<i>Blechnum orientale</i> ,	<i>Impatiens</i> sp.,	<i>Selaginella</i> sp.,
<i>Calanthe herbacea</i> ,	<i>Liparis paradoxa</i> ,	<i>Sonerila</i> sp.,
<i>C. lyroglossa</i> ,	<i>Mapania</i> spp. (2 species),	<i>Sphenomeris chinensis</i> ,
<i>Collabium assamicum</i> ,	<i>Mischobulbum cordifolium</i> ,	<i>Tacca plantaginea</i> ,
<i>Colocasia</i> sp.,	<i>Mondapsis petelotii</i> ,	<i>Vrydagzinea albida</i> ,
<i>Colysis digitata</i> ,	<i>Ophiopogon latifolius</i> ,	<i>Zingiber</i> sp.
<i>Costus speciosus</i> ,	<i>Ophiopogon</i> sp.,	
<i>Curculigo</i> sp.,	<i>Ophiorrhiza baviensis</i> ,	

Mosses and lichens occasionally forming ground stratum are not common. Few species of mosses (particularly Bryopsida and Marchantiopsida) sometimes form cover 2–3% in wet shady places, but often this stratum is absent.

Numerous epiphytes are very typical in riparian forests in the studied area. They form integral characteristic element of this habitats including large numerous clumps of epiphytic nest ferns, such as *Asplenium nidus* and *Aglaomorpha coronans*. Another epiphytic dominants are other ferns and orchids, particularly *Appendicula cornuta*, *Coelogyne fimbriata*, *Epigeneium chapaense*, *Lepisorus* spp. (4 species), *Nephrolepis cordifolia*, *Rhynchotechum* sp. and *Selliguea lateritia*. Creeping epiphytic lianas and climbers occur abundantly, covering sometimes boles of all large trees in shady slopes along rivers. Among the very common species are *Aeschynanthus* spp. (3 species), *Davallia divaricata*, *D. repens*, *Dischidia* sp., *Ficus pumila*, *Hoya* sp., *Medinilla alternifolia*, *M. pterocaula*, *Pothos* sp., *Psychotria serpens*, *Pyrrosia* sp., *Rhaphidophora* sp. and *Scindapsus* sp. Many species of mosses (particularly from Bryopsida) completely cover branches of trees above streams, hanging often up to 15–20 cm.

The more or less common associated epiphytic species here are as follows:

<i>Asplenium prolongatum</i> ,	<i>E. pusilla</i> ,	<i>Oberonia</i> sp.,
<i>Bulbophyllum insulsum</i> ,	<i>E. siamensis</i> ,	<i>Pholidota chinensis</i> ,

<i>B. penicillium</i> ,	<i>Grammithis</i> sp.,	<i>Trichomanes</i> sp.,
<i>Bulbophyllum</i> spp. (2 species),	<i>Hymenophyllum</i> sp.,	<i>Trichotosia velutina</i> ,
<i>Coelogyne fimbriata</i> ,	<i>Lepisorus</i> sp.,	<i>Vaccinium</i> sp.,
<i>Eria amica</i> ,	<i>Liparis chapaense</i> ,	<i>Vittaria elongata</i> .
<i>E. gagnepaini</i> ,	<i>L. petelotii</i> ,	
<i>E. paniculata</i> ,	<i>L. stricklandiana</i> ,	

Lianas and climbers in riparian plant communities reach highest diversity in the area. Among main dominant species are giant woody vines 30–40 m long with characteristically flat undulated stems up to 40 cm wide, such as *Tetrastigma planicaule*, *Tetrastigma* sp. and *Bauhinia* spp. (2 species). Here also are numerous other woody and herb lianas like *Acacia pinnata*, *Albizia* sp., *Bauhinia touranensis*, *Clematis* sp., *Dalbergia* sp., *Desmos chinensis*, *Embelia pulchella*, *Fissistigma balansae*, *Gnetum* sp., *Paederia* sp., *Piper* sp., *Rubus* spp. (3 species), *Smilax* spp. (2 species), *Stauntonia* sp., *Strychnos* sp., *Uncaria* sp., *Vernonia sylvatica*, *Vernonia* sp., *Zanthoxylum* sp., as well as numerous immature representatives of Annonaceae, Apocynaceae and Rubiaceae.

Wet stream boulders, rocky outcrops on river slopes and waterfall cliffs are habitats of many lithophytic species, particularly ferns, such as *Abacopteris* sp., *Angiopteris somae*, *Angiopteris* sp., *Asplenium prolongatum*, *Blechnum orientale*, *Bolbitis* sp., *Colysis digitata*, *Elaphoglossum* sp., *Leptochilus* sp., *Nephrolepis cordifolia*, *Osmunda vachellii*, *Vittaria forrestiana*. Other common lithophytes in riparian communities are *Acorus gramineus*, *Amorphophallus* sp., *Begonia* spp. (5 species), *Bulbophyllum* sp., *Carex* sp., *Costus speciosus*, *Dendrobium chrysanthum*, *Ficus pyriformis*, *Heterogonium* sp., *Liparis stricklandiana*, *Ophiopogon latifolius*, *Pellionia* spp. (4 species), *Pholidota chinensis*, *Pilea* sp., *Stuednera* sp. and *Tupistra albiflora*. Moss species (particularly from Bryopsida and Marchantiopsida) often cover 100% of surface of shady wet stream rocks. Among lithophytic creeping vines very common *Ficus pumila* and *Pyrrosia* sp.

Plants of specific life forms include characteristic epiphytic shrub – *Schefflera* sp., epiphytic climbing tree – *Fagraea ceylanica*, and epiphytic tree-stranglers – *Ficus* spp. (2–3 species).

### General notes on the flora

Like any montane floras, the highland flora of mountains of Van Ban District has a complex character. At low elevations up to 1400 m a.s.l., in mountain belt of lowland and submontane forests it is comprised mainly of warm loving elements. This is genuine tropical flora, which approaches the typical floras of North Indochinese Province of Palearctic floristic kingdom (Averyanov, et al., 2003). However, at higher elevations, in the belt of lower montane and upper montane tropical woods, the flora acquires temperate character, which approximates the floras typical for Sikang-Yunnan floristic province of Holarctic floristic kingdom. Thus one of the key important floristic

borders of Asia, lies in Van Ban montane uplands at elevations about 1400 m a.s.l. This line separates Holarctic and Paleotropical floristic realms. According to taxonomic composition, both components of the flora may be classified as rather tropical floras.

Like any other tropical floras, the flora of Van Ban mountains includes considerable portion of orchids and ferns. Both these groups fill the first position in the top ten families in the flora, that underlines its tropical character (Tolmachev, 1974). According to preliminary estimation each of these groups include from 6 to 8% of plant species occurring in the studied area.

Most orchids in Van Ban area are usually epiphytic. Among the most common species are:

<i>Agrostophyllum brevipes</i> ,	<i>Dendrobium acinaciforme</i> ,	<i>L. mannii</i> ,
<i>Appendicula hexandra</i> ,	<i>D. aduncum</i> ,	<i>L. petelotii</i> ,
<i>Biermannia calcarata</i> ,	<i>D. brymerianum</i> ,	<i>L. stricklandiana</i> ,
<i>Bulbophyllum affine</i> ,	<i>D. chrysanthum</i> ,	<i>Monomeria barbata</i> ,
<i>B. atrosanguineum</i> ,	<i>D. longicornu</i> ,	<i>Oberonia pumilio</i> ,
<i>B. bisetoides</i> ,	<i>D. nobile</i> ,	<i>Otochilus</i> sp.
<i>B. emarginatum</i> ,	<i>D. thyrsiflorum</i> ,	<i>Panisea tricallosa</i> ,
<i>B. hymenanthum</i> ,	<i>Epigeneium chapaense</i> ,	<i>Pholidota articulata</i> ,
<i>B. insulsum</i> ,	<i>Eria amica</i> ,	<i>Ph. chinensis</i> ,
<i>B. penicillium</i> ,	<i>E. gagnepainii</i> ,	<i>Schoenorchis gemmata</i> ,
<i>B. reptans</i> ,	<i>E. paniculata</i> ,	<i>Sunipia scariosa</i> ,
<i>B. retusiusculum</i> ,	<i>E. pannea</i> ,	<i>Thrixspermum formosanum</i> ,
<i>Callostylis rigida</i> ,	<i>E. pusilla</i> ,	<i>Trichotomia dasyphylla</i> ,
<i>Ceratostylis himalaica</i> ,	<i>E. siamensis</i> ,	<i>T. microphylla</i> ,
<i>C. pygmaea</i> ,	<i>E. thao</i> ,	<i>T. velutina</i> ,
<i>Coelogyne fimbriata</i> ,	<i>Gastrochilus calceolaris</i> ,	<i>Vanilla annamica</i> .
<i>C. lockii</i> ,	<i>Liparis chapaensis</i> ,	
<i>Cymbidium floribundum</i> ,	<i>L. distans</i> ,	

Terrestrial orchids also form a rather large ecological group, among which are the following regularly observed species:

<i>Acanthephippium striatum</i> ,	<i>C. lancifolium</i> ,	<i>Rhomboda petelotii</i> ,
<i>Anoectochilus elwesii</i> ,	<i>Erythrodes blumei</i> ,	<i>Spiranthes sinensis</i> ,
<i>A. roxburghii</i> ,	<i>Goodyera foliosa</i> ,	<i>Tainia angustifolia</i> ,
<i>Apostasia wallichii</i> ,	<i>G. fumata</i> ,	<i>T. latifolia</i> ,
<i>Calanthe aleizettii</i> ,	<i>G. schlechtendaliana</i> ,	<i>T. viridifusca</i> ,
<i>C. densiflora</i> ,	<i>G. viridiflora</i> ,	<i>Tropidia angulosa</i> ,
<i>C. herbacea</i> ,	<i>Hetaeria biloba</i> ,	<i>Vrydagzynea albida</i> ,
<i>C. lyroglossa</i> ,	<i>Liparis paradoxa</i> ,	<i>Zeuxine nervosa</i> ,
<i>Cephalantheropsis obcordata</i> ,	<i>Mischobulbum cordifolium</i> ,	<i>Z. parvifolia</i> .
<i>Collabium assamicum</i> ,	<i>Phaius mishmensis</i> ,	
<i>Cymbidium ensifolium</i> ,	<i>Platanthera angustata</i> ,	

Other orchids in Van Ban area are obligate lithophytes (*Diglyphosa evrardii*, *Diplomeris pulchella*, *Pleione grandiflora*) and achlorophyllous mycotrophic saprophytes (*Didymoplexiopsis khiriwongensis*, *Galeola nudifolia*, *Lecanorchis javanica*). The total number of orchid species in the flora of Van Ban mountain area may be initially estimated at 160–180 species.

Ferns are the next largest taxonomic group in the mountain flora of Van Ban District. The most common species observed here are:

<i>Angiopteris somae</i> ,	<i>Crepidomanes auriculatum</i> ,	<i>Microlepia hookeriana</i> ,
<i>Anogramme microphylla</i> ,	<i>Crypsinus griffithianus</i> ,	<i>Monachosorum henryi</i> ,
<i>Arthromeris wallichiana</i> ,	<i>C. rhyrachophyllus</i> ,	<i>Neochheiropteris ningpoensis</i> ,
<i>Asplenium cheilosorum</i> ,	<i>Cyathea contaminans</i> ,	<i>Onychium lucidum</i> ,
<i>A. ensiforme</i> ,	<i>C. gigantea</i> ,	<i>Osmunda banksiaefolia</i> ,
<i>A. griffithianum</i> ,	<i>C. podophylla</i> ,	<i>O. vachellii</i> ,
<i>A. laciniatum</i> ,	<i>C. spinulosa</i> ,	<i>Phymatosorus lucidus</i> ,
<i>A. lepturus</i> ,	<i>Cyrtomium fraxinellum</i> ,	<i>Plagiogyria stenoptera</i> ,
<i>A. nidus</i> ,	<i>Davallia divaricata</i> ,	<i>P. yunnanensis</i> ,
<i>A. normale</i> ,	<i>D. repens</i> ,	<i>Pleocnemia irregularis</i> ,
<i>A. prolongatum</i> ,	<i>Diacalpe aspidioides</i> ,	<i>Polypodium amoenum</i> ,
<i>A. pseudolaserpitifolium</i> ,	<i>Diplazium dilatatum</i> ,	<i>P. bourretii</i> ,
<i>A. tenerum</i> ,	<i>D. donianum</i> ,	<i>Polystichum squarrosom</i> ,
<i>A. tenuifolium</i> ,	<i>D. griffithii</i> ,	<i>P. tsus-simense</i> ,
<i>A. wrightii</i> ,	<i>D. pullingeri</i> ,	<i>Pyrrhosia porosa</i> ,
<i>Blechnum orientale</i> ,	<i>D. sorzogonense</i> ,	<i>Scleroglossum minus</i> ,
<i>Bolbitis appendiculata</i> ,	<i>Dipteris chinensis</i> ,	<i>Selliguea lateritia</i> ,
<i>B. christensenii</i> ,	<i>Elaphoglossum angulatum</i> ,	<i>Stegnogramme griffithii</i> ,
<i>Cheiropleuria bicuspis</i> ,	<i>Lepisorus obscuro-venulosa</i> ,	<i>Tectaria simonsii</i> ,
<i>Colysis digitata</i> ,	<i>L. subrostratus</i> ,	<i>T. subtriphylla</i> ,
<i>C. dissimilialata</i> ,	<i>L. thunbergianus</i> ,	<i>T. yunnanensis</i> ,
<i>C. longisora</i> ,	<i>Leptochilus decurrens</i> ,	<i>Vittaria forrestiana</i> ,
<i>Coniogramme intermedia</i> ,	<i>Lindsaea javanensis</i> ,	<i>Woodwardia unigemmata</i> .
<i>Coryphopteris hirsutipes</i> ,	<i>Loxogramme salicifolia</i> ,	

They belong to such tropical families as Adiantaceae, Aspleniaceae, Blechnaceae, Cyatheaceae, Davalliaceae, Dennstaedtiaceae, Dipteridaceae, Dryopteridaceae, Grammitidaceae, Hymenophyllaceae, Lomariopsidaceae, Marattiaceae, Osmundaceae, Plagiogyriaceae, Polypodiaceae, Thelypteridaceae, Vittariaceae and Woodsiaceae. Among living forms, here dominate epiphytes, terrestrials and lithophytes. Significant role in habitats have woody ferns, which are very common in the studied area at elevations 700–1100 m a.s.l.

Among other largest families, representatives of which play first role in taxonomic composition of the whole flora may be mentioned Annonaceae, Cyperaceae, Ericaceae, Euphorbiaceae, Gesneriaceae, Lauraceae, Melastomataceae, Myrsinaceae, Rubiaceae and Urticaceae. At the same time in lowland and submontane wood formations at low elevation first role in first and second forest strata belongs to such

genuine tropical families as:

Anacardiaceae (*Choerospondias axillaris*),  
 Dipterocarpaceae (*Dipterocarpus retusus*, *Hopea mollissima*),  
 Elaeocarpaceae (*Elaeocarpus petiolatus*, *E. tonkinensis*, *Elaeocarpus* sp.),  
 Fabaceae (*Albizia* sp., *Archidendron balansae*, *Ormosia* sp.),  
 Lauraceae (*Cinnamomum* sp.),  
 Meliaceae (*Aglaia edulis*, *Aglaia* sp.),  
 Moraceae (*Ficus* spp.),  
 Myristicaceae (*Knema globularia*),  
 Myrtaceae (*Syzygium* spp.),  
 Podocarpaceae (*Dacrycarpus imbricatus*),  
 Polygalaceae (*Xanthophyllum urophyllum*),  
 Proteaceae (*Helicia* spp.),  
 Rhizophoraceae (*Carallia brachiata*, *C. lanceaeifolia*),  
 Sapindaceae (*Nephelium milliferum*),  
 Sapotaceae (*Eberhardtia* sp.),  
 Ulmaceae (*Gironniera subaequalis*).

A rare tree subendemic to Vietnam – *Platanus kerrii* (Platanaceae) sometimes appears as occasional dominant of canopy stratum in small remnants of gallery forests at lowest elevations in the area at about 300 m a.s.l.. These last forest remnants, which still survive along rivers in few places of the area, give us bleak approximate vision on primary lowland valley vegetation, which became extinct here many decades ago.

At elevations over 1400 m a.s.l., in lower montane and upper montane forests warm loving trees give way to representatives of families, which are more typical to subtropical and temperate Asia. Main dominants of highest forest strata in these woods belong to another group of families. Among them are:

Aceraceae (*Acer laurinum*, *Acer* spp.),  
 Betulaceae (*Carpinus* sp.),  
 Cupressaceae (*Fokienia hodginsii*),  
 Ericaceae (*Rhododendron basilicum*, *R. cyanocarpum*, *Rhododendron* spp.),  
 Fagaceae (*Castanopsis tonkinensis*, *Lithocarpus kunstleri*, *L. laotica*, *L. truncatus*,  
*Lithocarpus* spp., *Quercus annulata*, *Quercus* spp.),  
 Hamamelidaceae (*Exbucklandia populnea*, *Rhodoleia championii*),  
 Illiciaceae (*Illicium majus*, *I. petelotii*, *I. tsaii*),  
 Lauraceae (*Litsea* spp.),  
 Magnoliaceae (*Liriodendron chinense*, *Michelia* spp.),  
 Rhoipteleaceae (*Rhoiptelea chiliantha*),  
 Rosaceae (*Sorbus* spp.),  
 Styrcaceae (*Rehderodendron macrocarpum*, *Styrax* spp.),  
 Symplocaceae (*Symplocos* spp.),  
 Taxodiaceae (*Taiwania cryptomerioides*),  
 Theaceae (*Anneslea fragrans*, *Schima wallichii*, *Schima* sp.).

On tops of mountains at elevation over 2200 m, main dominants of dwarf elfin forests are numerous ericaceous trees and shrubs. Among them may be seen many species of *Rhododendron*, *Pieris*, *Vaccinium* and *Enkianthus*. Common dominants of montane forests (*Illicium tsaii*, *Rhodoleia championii*, *Schima wallichii*, *Sorbus* sp., *Symplocos* sp.) occur here as regular associated species. Many shrubs and trees in these habitats are deciduous. As a result, upper mountain vegetation during winter season bears certain resemblance with temperate Asian floras. This resemblance is underlined by numerous floristic elements connected in their distribution with montane and temperate Asia. Among them are species of such genera as:

<i>Acer</i> ,	<i>Daphne</i> ,	<i>Lysimachia</i> ,	<i>Primula</i> ,
<i>Acorus</i> ,	<i>Dichocarpum</i> ,	<i>Paris</i> ,	<i>Ranunculus</i> ,
<i>Actinidia</i> ,	<i>Diplazium</i> ,	<i>Pedicularis</i> ,	<i>Sedum</i> ,
<i>Asarum</i> ,	<i>Disporum</i> ,	<i>Platanthera</i> ,	<i>Sorbus</i> ,
<i>Astilbe</i> ,	<i>Dryopteris</i> ,	<i>Pleione</i> ,	<i>Swertia</i> ,
<i>Aucuba</i> ,	<i>Eleocharis</i> ,	<i>Fragaria</i> ,	<i>Viola</i> .
<i>Carex</i> ,	<i>Gentiana</i> ,	<i>Polypodium</i> ,	
<i>Carpinus</i> ,	<i>Lonicera</i> ,	<i>Polystichum</i> ,	

Some of these species, like *Astilbe rivularis*, *Fragaria nilagirica*, *Lysimachia laxa*, *Paris delavayi*, *P. polyphylla* and *Viola* spp. are quite common at elevations higher than 1800–1900 m a.s.l. They form integral herbaceous element of the primary plant communities, both in close woody formations, and in more or less open habitats on steep montane slopes.

Specific secondary forests were observed in pristine conditions of the studied highland area on numerous rockslides and soil slips, as well as on enough wet stream slopes after forest fire. These rather open woods are composed on high elevations mainly with fast growing deciduous aboriginal trees like *Carpinus* sp., *Liriodendron chinense*, *Styrax* sp. and *Rhoiptelea chiliantha*. Among evergreen trees here also common *Litsea* spp. and *Rhodoleia championii*.

Secondary forests have still limited distribution at high elevations in the studied area. Main role in the formation of the characteristic landscape face of Lang Cung Mountains belong to majestic ancient relictual coniferous forests comprised of *Fokienia hodginsii*.

According to florogenetic composition, the flora of Lang Cung Mountains has closest similarity with montane flora of south-eastern Himalayas. Thus, the largest part (about 35%) of orchids discovered in mountain forests of Van Ban District has clear Himalayan connections. Among such orchids are:

<i>Acanthephippium striatum</i> ,	<i>Bulbophyllum hymenanthum</i> ,	<i>Collabium assamicum</i> ,
<i>Agrostophyllum brevipes</i> ,	<i>B. penicillium</i> ,	<i>Dendrobium longicornu</i> ,
<i>Anoectochilus elwesii</i> ,	<i>Calanthe herbacea</i> ,	<i>D. nobile</i> ,
<i>A. roxburghii</i> ,	<i>Cephalantheropsis obcordata</i> ,	<i>D. thyrsiflorum</i> ,
<i>Apostasia wallichii</i> ,	<i>Ceratostylis himalaica</i> ,	<i>Eria pannea</i> ,
<i>Appendicula hexandra</i> ,	<i>Coelogyne fimbriata</i> ,	<i>E. pusilla</i> ,



<i>Erythrodes blumei</i> ,	<i>Liparis paradoxa</i> ,	<i>Pholidota chinensis</i> ,
<i>Galeola nudifolia</i> ,	<i>Mischobulbum cordifolium</i> ,	<i>Platanthera angustata</i> ,
<i>Goodyera foliosa</i> ,	<i>Monomeria barbata</i> ,	<i>Tainia viridifusca</i> ,
<i>G. fumata</i> ,	<i>Panisea tricallosa</i> ,	<i>Zeuxine nervosa</i> .
<i>G. schlechtendaliana</i> ,	<i>Phaius mishmensis</i> ,	

Relatively few species of the flora have distinct connections with floras of southern part of Indochinese Peninsula and Malesia. Among orchids of such relations in Lang Cung montane flora are *Calanthe densiflora*, *C. lyroglossa*, *Callostylis rigida*, *Eria amica*, *E. siamensis*, *Goodyera viridiflora*, *Hetaeria biloba*, *Lecanorchis javanica*, *Trichotosia microphylla* and *Vrydagzynea albida* (totally less than 11% of discovered orchid species).

Considerable number of species observed in the flora of Lang Cung Mountains has wide distribution in tropical Asia. Within Orchidaceae this group represents about 35% of discovered species.

Vietnamese endemic and sub-endemic species having very strict distribution form large and very important integral part of the flora. This group of species outlines deep specificity of the flora and high level of its endemism. Among orchids the following species belong to this group:

<i>Biermannia calcarata</i> ,	<i>Coelogyne lockii</i> ,	<i>E. thao</i> ,
<i>Bulbophyllum atosanguineum</i> ,	<i>Cymbidium floribundum</i> ,	<i>Liparis chapaensis</i> ,
<i>B. bisetoides</i> ,	<i>Didymoplexiopsis khiriwongensis</i> ,	<i>L. petelotii</i> ,
<i>B. insulsum</i> ,	<i>Diglyphosa evrardii</i> ,	<i>Pleione grandiflora</i> ,
<i>Calanthe aleizettii</i> ,	<i>Epigeneium chapaense</i> ,	<i>Rhomboda petelotii</i> .
<i>Ceratostylis pygmaea</i> ,	<i>Eria gagnepainii</i> ,	

This group represents about 19% species of the family Orchidaceae in the flora of the region. Among the 7 species are endemics of Sikang-Yunnan floristic province (*Coelogyne lockii*, *Cymbidium floribundum*, *Epigeneium chapaense*, *Eria gagnepainii*, *Liparis petelotii*, *Pleione grandiflora*, *Rhomboda petelotii*). Another 9 species are strict Vietnamese endemics. They are *Biermannia calcarata*, *Bulbophyllum atosanguineum*, *B. insulsum*, *Calanthe aleizettii*, *Ceratostylis pygmaea*, *Diglyphosa evrardii*, *Eria thao* and *Liparis chapaensis*. Some sub-endemic species, like *Didymoplexiopsis khiriwongensis* and *Bulbophyllum bisetoides* have Indo-chinese range occurring beside Viet Nam in northern Thailand.

A number of species in the flora of Van Ban area appear as distinct geographical markers, which outline southern border of Sikang-Yunnan floristic province. Among them are:

<i>Ainsliaea reflexa</i> ,	<i>I. tsaii</i> ,	<i>Taiwania cryptomerioides</i> ,
<i>Angiopteris somae</i> ,	<i>Liriodendron chinense</i> ,	<i>Tsuga chinensis</i> ,
<i>Asplenium laciniatum</i> ,	<i>Plagiogyria yunnanensis</i> ,	<i>Vernonia sylvatica</i> .
<i>Huperzia cancellata</i> ,	<i>Pleione grandiflora</i> ,	
<i>Illicium petelotii</i> ,	<i>Rhoiptelea chiliantha</i> ,	

According to basic species composition, the flora of Lang Cung Mountains is typical of montane flora in northern part of Indochinese Peninsula. It represents relictual derivative of ancient Tertiary flora that once occupied wide tropical and subtropical areas of Europe, Asia and North America approximately 40–70 million years ago. Due to subsequent climate cooling and increased aridity this humid warm-loving flora was shifted during Coenozoic age to South-East Asia. Lang Cung Mountain flora like other montane floras of Indochina is typical variant of floras of such genesis. It exhibits surprisingly large proportion of archaic genera well represented in available fossils record of the Upper Cretaceous and Lower Tertiary, recorded from Europe, East Asia and North America (Kubitzki, Krutzsch, 1998; Martinetto, 1998; Averyanov, Nguyen Tien Hiep, 2002). Among them are numerous species of such families as:

Actinidiaceae (*Actinidia petelotii*, *Actinidia* spp.),  
 Annonaceae (*Dasymaschalon rostratum*, *Desmos* sp., *Fissistigma balansae*,  
*Miliusa* sp., *Polyalthia* sp.),  
 Betulaceae (*Carpinus* sp.),  
 Cephalotaxaceae (*Amentotaxus argotaenia*),  
 Cupressaceae (*Fokienia hodginsii*),  
 Fagaceae (*Castanopsis tonkinensis*, *Lithocarpus kunstleri*, *L. laotica*,  
*L. truncatus*, *Lithocarpus* spp., *Quercus annulata*, *Quercus* spp.),  
 Hamamelidaceae (*Exbucklandia populnea*, *Rhodoleia championii*),  
 Lardizabalaceae (*Stauntonia* sp.),  
 Lauraceae (*Actinodaphne* sp., *Cinnamomum* sp., *Cryptocarya* sp., *Litsea* spp.),  
 Magnoliaceae (*Liriodendron chinense*, *Magnolia* sp., *Manglietia* sp.,  
*Michelia* spp., *Paramichelia* sp.),  
 Pinaceae (*Tsuga chinensis*),  
 Platanaceae (*Platanus kerrii*),  
 Podocarpaceae (*Dacrycarpus imbricatus*, *Podocarpus neriifolius*),  
 Ranunculaceae (*Dichocarpum* sp., *Ranunculus* spp.),  
 Rhoipteleaceae (*Rhoiptelea chiliantha*),  
 Sabiaceae (*Meliosma lepidota*, *Sabia parviflora*),  
 Taxodiaceae (*Taiwania cryptomerioides*),  
 Theaceae (*Anneslea fragrans*, *Schima wallichii*).

Among mentioned families, the family Rhoipteleaceae is subendemic to the area. It is remarkable that its only representative *Rhoiptelea chiliantha* is common integral component of montane forests in uplands of Lang Cung mountain system. Another subendemic family here is Petrosaviaceae. It includes in the flora one species – *Petrosavia sinii*. This small achlorophyllous mycotrophic herb common in highland woods exhibits the most primitive gynoeceum known in monocots.

In respect of its origin and taxonomic composition, the flora of Lang Cung Mountains represents uncial remnant relictual formation, which may serve as a model for the study of extinct forest floras and vegetation types widely distributed in Northern

Hemisphere during Tertiary age. This area of South-East Asia may be the birthplace and cradle of the Holarctic and even Paleotropic flora (Wu Z.Y. & Wu S.G., 1998). Discovery during the first reconnaissance explorations of highland flora of Lang Cung Mountains of some species new to the flora of Viet Nam (*Ainsliaea reflexa*, *Begonia grandis*, *Bulbophyllum penicillium*, *Ranunculus nephelogenes*, *Vernonia sylvatica*) and new species for science (*Bulbophyllum atosanguineum*, *Cheilanthes* sp. nov., *Sedum vietnamense*) designates this flora as very rich but still poorly investigated.

### Conservation

Despite proposed conservation status, the forests of Van Ban highland area are presently under serious press of uncontrolled exploitation by the local people community. Timber, medicinal and ornamental plants are main objects of commercial interests of local and international trade, which stimulate illegal exploitation of the natural resources of the area.

The large trees, timber of which are still widely explored in the area for building construction and sale, include *Castanopsis* spp., *Fokienia hodginsii*, *Hopea mollissima*, *Lithocarpus* spp., *Madhuca pasquieri* and *Michelia* spp. Among medicinal plants, commonly collected for export as traditional oriental drags in Lang Cung Mountains, are such orchids as *Anoectochilus elwesii*, *A. roxburghii*, *Goodyera foliosa*, *Hetaeria biloba*, *Platanthera angustata*, *Rhomboda petelotii*, *Spiranthes sinensis* and different species of *Dendrobium*. Here occur also many other plants, locally used in primitive medicine of national minorities and in traditional oriental medicine. Among such species are:

<i>Actinidia</i> sp.,	<i>I. petelotii</i> ,	<i>Schefflera</i> sp.,
<i>Ardisia</i> spp.,	<i>I. tsaii</i> ,	<i>Strychnos</i> sp.,
<i>Aristolochia</i> sp.,	<i>Kadsura coccinea</i> ,	<i>Tacca plantaginea</i> ,
<i>Asarum glabrum</i> ,	<i>Paris delavayi</i> ,	<i>Viscum articulatum</i> .
<i>Ilex</i> sp.,	<i>P. polyphylla</i> ,	
<i>Illicium majus</i> ,	<i>Pedicularis</i> sp.,	

Among indigenous plants of Lang Cung Mountains having great potential for ornamental horticulture are numerous orchids, such as *Calanthe aleizettii*, *Cymbidium floribundum*, *C. ensifolium*, *C. lancifolium*, *Dendrobium aduncum*, *D. brymerianum*, *D. chrysanthum*, *D. longicornu*, *D. nobile*, *D. thyrsiflorum*, *Diplomeris pulchella*, *Mischobulbum cordifolium*, *Pholidota articulata*, *Ph. chinensis* and *Pleione grandiflora*, as well as representatives of many other angiosperms families. Among them are species of such genera as:

<i>Actinidia</i> ,	<i>Astilbe</i> ,	<i>Disporum</i> ,
<i>Aeschynanthus</i> ,	<i>Aucuba</i> ,	<i>Dracaena</i> ,
<i>Aglaonema</i> ,	<i>Begonia</i> ,	<i>Enkianthus</i> ,
<i>Amorphophallus</i> ,	<i>Crawfordia</i> ,	<i>Gentiana</i> ,
<i>Arisaema</i> ,	<i>Curculigo</i> ,	<i>Hedera</i> ,

<i>Hoya</i> ,	<i>Peliosanthes</i> ,	<i>Sedum</i> ,
<i>Huperzia</i> ,	<i>Peperomia</i> ,	<i>Streptolirion</i> ,
<i>Ixora</i> ,	<i>Piper</i> ,	<i>Tupistra</i> ,
<i>Liriodendron</i> ,	<i>Pieris</i> ,	<i>Vaccinium</i> ,
<i>Lonicera</i> ,	<i>Polygonatum</i> ,	<i>Viola</i> .
<i>Mondopsis</i> ,	<i>Rhododendron</i> ,	
<i>Ophiopogon</i> ,	<i>Schefflera</i> ,	

Numerous ferns and some palms, like *Licuala ternata* and *Livistona* sp. common in uplands of Van Ban District also belong to this group of potential ornamental plants.

Taking into consideration the current levels of local exploration, threat of extinction due to habitat destruction and general species rarity in the territory of Viet Nam, some species of the Lang Cung flora deserve status of IUCN categories of high threat (IUCN, 1994). According to our preliminary observations, these species may be classified as follows:

**CR** (critically endangered): *Taiwania cryptomerioides*.

**EN** (endangered): *Fokienia hodginsii*, *Tsuga chinensis*.<sup>9</sup>

**VU** (vulnerable): *Amentotaxus argotaenia*, *Anoectochilus elwesii*, *A. roxburghii*, *Cymbidium ensifolium*, *C. floribundum*, *Dendrobium aduncum*, *D. brymerianum*, *D. chrysanthum*, *D. longicornu*, *D. nobile*, *D. thyrsiflorum*, *Diplomeris pulchella*, *Fokienia hodginsii*, *Lecanorchis javanica*, *Madhuca pasquieri*, *Pleione grandiflora*, *Rhomboda petelotii*.

Other plant species of Van Ban highland area may now be placed according to available data under **LR** (lower risk), **DD** (deficit data) and **NE** (not evaluated) categories. Detailed studies of their status in the flora are the subject of further field botanical investigations.

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<sup>9</sup> This status is applied not only to the species, but also to the forest stands composed with ripe samples of *Fokienia hodginsii* and *Tsuga chinensis*, which represent unique relictual plant formations one of the oldest and most endangered on our planet.

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## РЕЗЮМЕ

Краткий предварительный обзор флоры и растительности горной системы Ланг Кунг, лежащей на юге района Ван Бан, провинции Лао Кай в северном Вьетнаме, проведен на основе оригинальных данных, собранных при проведении экспедиционных полевых работ в течение 2001–2002 годов. Описание растительности и анализ флоры основан на изучении модельных площадок и обширном гербарии, отражающем таксономический состав всех местообитаний, характерных для изучаемого региона. Сомкнутые вечнозеленые тропические муссонные (сезонно-влажные) леса являются главным типом растительности в изученной области. Они подразделены на низкогорные, предгорные, среднегорные и высокогорные леса. Последние два типа лесов, наиболее полно сохранившие свой первичный облик, описываются в работе с особой детальностью. Характер растительности

и систематический состав флоры гор Ланг Кунг типичен для южной оконечности высокогорий Сиканг-Юньнанской флористической провинции, представленных во Вьетнаме хребтом Хоанг Лиен Шон. Эта флора представляет производное древней третичной флоры Евразии и включает очень большое число архаичных родов, богато представленных в верхнемеловых и раннетретичных флорах Европы и Восточной Азии. По своему составу и происхождению эта флора представляет уникальное реликтовое образование, которое может служить своеобразной моделью для реконструкции биотических условий, характерных для северного полушария, существовавших в третичное время.

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