

Phytogeographic review of Vietnam and adjacent areas of Eastern Indochina

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The main phytogeographic regions within the eastern part of the Indochinese Peninsula are delimited on the basis of analysis of recent literature on geology, geomorphology and climatology of the region, as well as numerous recent literature information on phytogeography, flora and vegetation. The following six phytogeographic regions (at the rank of floristic province) are distinguished and outlined within eastern Indochina: Sikang-Yunnan Province, South Chinese Province, North Indochinese Province, Central Annamese Province, South Annamese Province and South Indochinese Province. Short descriptions of these floristic units are given along with analysis of their floristic relationships. Special floristic analysis and consideration are given to the *Orchidaceae* as the largest well-studied representative of the Indochinese flora.

1. Background

The Socialist Republic of Vietnam, comprising the largest area in the eastern part of the Indochinese Peninsula, is situated along the southeastern margin of the Peninsula. Vietnam extends from 8°30' N to 23°30' N latitude, a distance of more than 1600 km from its northern border with the People's Republic of China to its southernmost point at cape Camau. The east – west extent of the country is variable and not large, about 600 km in the north and only a little more than 40 km at its narrowest part within Quang Binh Province. The westernmost point of Vietnam is at the junction of the Laos, Vietnam and China (102°10' E) borders. The easternmost point of the continent is at cape Nai (109°27' E). The total land area of Vietnam is approximately 325360 sq. km.

The northeastern and southwestern frontiers of Vietnam are formed by the waters of the Bac Bo (Tonkin) and Thailand (Siam) Gulfs of the South China Sea. The coastline of mainland Vietnam extends nearly 3440 km. A large number of islands, mainly of continental origin and also numerous small coral atolls are included in the territory of Vietnam. The Annamite mountain chains, mainly the Den Dinh, Sam Sao, Hua Phan and Truong Son Ridges form the natural western Vietnamese boundary with Laos and Cambodia. The northern border with China lies within the

mountain systems of southeastern Yunnan and Guangxi. The contiguous inland border of Vietnam with China, Laos and Cambodia extends nearly 4639 km (Averyanov 1990c; Rundel 1999).

Three-quarters of Vietnam is hilly or mountainous. The largest mountain formations of the Indochina peninsula with the highest peaks of the region including Fan Si Pan (3143 m), Ta Giang Pinh (3096 m), Si Lung (3076 m), Luong (2985 m), Phoung Chang (2825 m), Lang Kung (2817 m) and a number of others are situated in the northwest of the country. The largest mountain systems are composed mainly of granite, gneiss, shale, schist and sandstones. Ancient highly metamorphosed and solid highly karst eroded limestone is very typical and widely distributed in the north portion of the country. Towards the east the mountains gradually give way to vast alluvial plains, often at minimum elevations. Southwards the mountainous regions are associated with relatively level and dissected plateaux, where average elevations are from 500 to 1500 m above sea level. The southern portion of the country is the vast partially swamped lowland plain of Me Cong River delta.

The hydrographic network within Vietnam is well-developed with in addition to numerous small and medium-sized streams and rivers flow the largest rivers within South-East Asia, including Song Hong (Hong Ha, or Red River) and Me Cong.

Vietnam, as well as the contiguous territories of Laos, Thailand and Cambodia making up the eastern section of the Indochinese Peninsula, support incredibly diverse vegetation types, rich plant communities and a wide variety of habitats. The incredible richness of the flora, the high level of biodiversity and diversity of vegetation types make general interpretations very difficult in the drawing of phytogeographic borders and the delimitation of basic phytogeographic regions.

In the past, the available biogeographic data on geology, climate, flora and vegetation within Vietnam were insufficient for even preliminary phytogeographic generalizations in the eastern part of the Indochinese Peninsula. As a result, only highly schematic and abstract floristic delimitations within the area were proposed for mainland South-East Asia (Good 1964; Takhtajan 1978, 1986; Wu Zhengyi & Wu Sugong 1998). Recent and impressive progress in botanical explorations and investigations, climatic interpretation and geological research within Vietnam, especially during the last decade, has improved our resolution and understanding of phytogeographic and biogeographic patterns within this area. The analysis of modern literature and recent original data on the geology, geomorphology, climate, flora and vegetation of Vietnam has allowed us to make better-circumscribed yet still very preliminary delimitations of the main phytogeographic regions in the eastern part of Indochinese Peninsula.

2. Geologic history of the region

Geologically, mainland South-East Asia forms a primary geomorphological unit composed primarily of Pre-Cambrian crystalline rock that consolidated to form a stable core in the Late Triassic. This unit, known as the South-East Asian or Sundaland prong of the Eurasian Plate, extends in a S to SE direction and includes the modern Indochina and the Malay Peninsulas, Sumatra and the western portions of Java, Kalimantan and Sulawesi. The Sunda Shelf, a shallow ocean area of the Gulf of Thailand and South China Sea, is also a core area of *Sundaland*. It was exposed many times during the Mesozoic and Tertiary as well as during the Pleistocene glacial periods when sea levels were lower (Rundel 1999).

One of the central portions of this Pre-Cambrian plate is a crystalline nucleus referred to as *Indosinia*, around which Indochina landforms were historically formed (Fromaget 1952). Three main obvious periods of tectonic folding took place around this ancient central block during the Paleozoic and early Mesozoic ages.

The earlier period of tectonic activity of Devonian age, known as the Caledonian Folding, occurred about 350–400 million years ago and outlined an enlarged stable block covering central and southern Vietnam, much of central and southern Laos, northeastern Cambodia and possibly much of northeastern Thailand. This core region, which has been termed *Annamia*, appears to have

remained relatively stable up to now (Fontaine & Workman 1978; Rundel 1999). In the peripheral zones of this block, especially along its north margin, numerous mountain systems were established oriented from northwest to southeast. Remnants of these ancient formations known as the *Tonkinides* can be observed in northern Vietnam, mainly in the north of Hoang Lien Son and in the northern portion of the Truong Son Ridges. The stable ancient Indosinian block was dissected at this time into several flat solid platforms that now appear in central and southern Vietnam as separate plateaux. The Kon Tum, Playcu, Dac Lac, Mo Nong, and Lam Vien (Dalat) Plateaux of southern Vietnam represent these crystalline platforms uplifted to various degrees. Along the faults bordering these plateaux later magmatic (mostly granite) intrusions and basalt flows occurred. During the Caledonian Folding sea levels fell. However after the Caledonian Orogenesis seas again covered large areas of Indosinia (Schzeglova 1957; Fridland 1961; Dovzikov *et al.* 1965a).

The oldest rocks within Indochina are the metamorphic crystalline complexes of Pre-Cambrian and early Paleozoic age, often remaining intact at least since the Devonian. Large exposed areas of these basement rocks exist today as plateaux in the central part of southern Vietnam. The impressive outcrops of these plateaux may be seen as high cliffs and bluffs along deep river canyons and on east-facing slopes along the continuous geological fault that outlines the seashore. During the same time, Mesozoic continental sediments covered plateaux on their western slopes now within Laos (Schzeglova 1957; Rundel 1999).

General uplifting of the Indosinian area and extensive regression of the sea during later Devonian and Carboniferous ages about 300–350 million years ago (Dovzikov *et al.* 1965a) were connected with the Hercynian Orogenesis. As a result of the Hercynian Folding, large mountain formations over wide areas of the central part of Vietnam from the coast to along the boundary with Laos were formed. Formation of considerable portions of the Truong Son (Annamite) Range in the south of Vietnam was also connected with the Hercynian Orogenesis. Devonian formations of the Hercynian Folding were consolidated by extensive granite intrusions during the middle Carboniferous Period. These granites are now exposed in many areas along the coast of central and southern Vietnam (Schzeglova 1957; Fridland 1961). The late Paleozoic, especially Permian ages were characterized by numerous wide depressions and transgressions of the sea that covered large areas of Indosinia again.

Orogenic activity became most intensive in the area during the early Mesozoic. Marine basins around the northern, western and southwestern margins of the Indosinia block were the focus of strong folding in a series of tectonic activities from the late Permian to the Triassic. This folding, termed the *Indosinian*, is most evident today in the large mountain areas of north Thailand and Laos, as well as along the borders of Vietnam with Cambodia and Laos. Extensive areas of granite rocks exposed in northern Vietnam are intrusives formed during this folding primarily in the late Permian and Triassic Periods. The formation of a number of mountain systems during the Indosinian Foldings, so-called *Indosidides* (Schzeglova 1957), was connected with tectonic activity resulting in a wide distribution of magmatic rocks like rhyolites, dacites and other related silicate rocks. Up to the late Triassic, the Indochina segment of continental crust was consolidated and uplifted preceding final sea regression and the formation of the modern landform configurations of mainland South-East Asia. A remarkable event of this time was the separation of Kalimantan from Indosinia (Schzeglova 1957). From this age, about 180 million years ago, until the present, the highland areas of Indosinia have experienced steady erosion (Schzeglova 1957; Rundel 1999) and sedimentation of considerable alluvial deposits, mainly sands. These Mesozoic sands cover large areas in southern Laos and can reach 2000 m in depth over the ancient crystalline basement of Indosinia. Mesozoic sands also occur along the coastline in southern Vietnam. Some local intrusive and volcanic activity was also present during this period and later, but they were of a rather limited character (Schzeglova 1957).

Shallow seas covered much of central and northern Indochina during the late Paleozoic and early Mesozoic, leading to the formation of extensive deposits of limestone. The spectacular karst topography of northern and central Vietnam is formed mainly by limestones of these ages and they

are mainly Devonian, Carboniferous, Permian and Triassic. However, limestones of Precambrian, Cambrian and Ordovician ages are also locally present (Dovzikov *et al.* 1965a, b). Numerous marine transgressions also continued during the Triassic, with seas covering eastern Cambodia and parts of southern Vietnam. Continental sedimentary formations characterized as *red beds (terrain rouge)* were also deposited over widespread areas at this time in Cambodia and southern Vietnam (Fontaine & Workman 1978).

In more recent history, the South-East Asian subcontinent and adjacent areas of southeastern China reacted as a single crystalline unit throughout the Cenozoic as surrounding areas exhibited considerable tectonic activity (Fontaine & Workman 1978). On the west, Indosinia was bordered by the Cretaceous-Tertiary orogenic formations of western and central Myanmar, and to the south by the Mesozoic-Cenozoic orogenies of Sumatra, Java, Kalimantan and the Philippines. At the same time Indosinia itself represented a distinctive geomorphologic unit of an older structural block of south central China that extended into northern Vietnam. The dividing line between these blocks, which roughly follows the present course of the Song Hong River, experienced differential movements from late Cretaceous to Eocene times. In Indosinia, tertiary tectonic activity was associated with steady uplift of montane terrains up to modern elevations of 2000–3000 m to the west and north, and subsidence of the Sunda shelf area to below sea level in the southeast (Rundel 1999). At the same time, formations of deep depressions and faults also occurred.

Along geological faults due to Cenozoic volcanic activity, enormous lava fields and basalt flows of Tertiary age cover thousands of square kilometers of land area in southern Vietnam. The largest of these areas are associated with the Pleicu, Dac Lac, Mo Nong, Haute Cochinchine and Djiring-Blao Plateaux of southern Vietnam (Rundel 1999). Smaller outliers of basalt cover also occur in north central Vietnam. On the Kon Tum plateau there are still a number of eroded volcanic cones of Tertiary age. Volcanic eruptions have occurred as recently as 1923 in the South China Sea off the southeastern coast of Vietnam (Schzeglova 1957).

Uplifting of northwestern mountains of Vietnam and some portions of Truong Son Ridge, as well as depression in the northeast and southern areas of the country, occurred from the later Tertiary up to present. Formation of the highest mountain systems of Vietnam like Phan Tsi Pan or Ngoc Linh is the result of this general uplift. On the other hand, these uplifts led to the accumulation of alluvial materials apparent in the Song Hong River delta and delta of the Me Cong (Schzeglova 1957). Smaller and less significant uplift also occurred in the central region of the country along coastline. As a result, a prominent Pleistocene marine terrace extends discontinuously along nearly 100 km of coastline near Phan Rang town in southeastern Vietnam (Rundel 1999).

Mountain erosion and extensive sedimentation of alluvial deposits were typical in the late Tertiary and early Quaternary history of Indochina. Quaternary alluvial deposits cover broad areas today in Cambodia, northern and southern Vietnam. Older alluvium of late Pleistocene reaches a thickness of more than 500 m in the eastern Me Cong delta. The Song Hong River basin around Hanoi is entirely covered by Quaternary alluvial deposits. Most recent Holocene deposits of pure quartz sand from modern beach sands extend inland from the coast of central Vietnam and alluvial terraces of this age are common along much of the coast over limestone substrates (Rundel 1999).

3. Modern geomorphology of Vietnam and adjacent areas

Generally the landscape of Vietnam is mountainous, with over three quarters of the land area covered in hills and mountains. The mountain areas fall superficially into three distinct regions:

1. The mountains of northeastern Vietnam, which lie northeast of the Song Hong River;
2. The Hoang Lien Son Ridge area of northwestern Vietnam northwest of the Song Hong River, which represents a southern extension of the Himalayas;
3. The long Truong Son (Annamite) Range, which forms the backbone of South-East Asia along the western border of Vietnam (Schzeglova 1957; Rundel 1999).

Other distinct geomorphologic areas of the country are coastal plains and the wide levelled alluvial valleys of Me Cong and Song Hong River.

3.1. Northeastern Montane Geomorphologic Region

The northeastern territory of Vietnam, lying northeast of the Song Hong River, represent a southern extension of the ancient Chinese block and structurally differs from the southern parts of South-East Asia (Dovzikov *et al.* 1965b; Rundel 1999). This block, the South China Platform, comprises western Guangxi, southern Kweichow and eastern Yunnan Provinces of China along with northeastern Vietnam. This area has experienced repeated uplift and subsidence events but relatively little deformation during its history. The landscape here is formed by a combination of exposed ancient metamorphic basement rock and eroded marine sediments deposited in the late Paleozoic and early Triassic. Most of these sediments are limestones that have been uplifted and highly eroded forming extensive karst topography appearing as a system of narrow remnant ridges and column-like mesae with very steep slopes and vertical bluffs. In Vietnam elevations of these formations are normally 300–700 m, however nearer to the border with China they often reach 1400–1600 m a.s.l. Numerous caves, sinkholes, underground rivers and seasonal small karst lakes are common in this area.

Tectonic activity in the late Triassic during Indosinian folding and in the late Carboniferous age led to local intrusions (Dovzikov *et al.* 1965b; Rundel 1999), forming a number of isolated granite mountain systems such as Tay Con Linh (2419 m), Pu Tha Ca (2274 m), Pia Da (1980 m) and Pia Oac (1930 m). These mountains are the highest peaks in the area, but most of the region is of only moderate relief. There is a prominent depression extending from Cao Bang town to the Pacific coast.

The northwest-southeast running valley of the Song Hong River separates the northeastern and the northwestern montane regions of Vietnam. Wide limestone terraces, extensive alluvial plains and low hills commonly bound the delta area of the Song Hong River and other major rivers of this region. The northeast coast is dotted with hundreds of small shale, sandstone and limestone islands. Highly eroded column-like limestone remnants are also observed in some inland areas of alluvial plains and low terraces of the Song Hong River delta.

3.2. Northwestern Montane Geomorphologic Region

The southern extension of the Himalayas (Henduan Mountains) extending from Yunnan into northern Vietnam is discernable as a number of high elevation ranges — Hoang Lien Son, Si Lung and Den Dinh. These form a large, clearly outlined montane region in the northwest of the country, with a relatively large area of uplands above 2000 m, and a number of peaks reaching 2500–3000 m a.s.l. The highest points of mainland South-East Asia are situated here. Among them Fan Si Pan (3143 m), Ta Giang Pinh (3096 m), Si Lung (3076 m), Luong (2985 m), Phoung Chang (2825 m), Lang Kung (2817 m) and many others. Most are formed by granite or quartzite intrusions in the late Mesozoic. To the south of main ridges lies an area of complex, folded parent material termed the Song Da and Dien Bien Phu synclines and the Song Ma anticline.

Continuous lines of limestone plateaux including those at Son La and Moc Chau with elevations up to 1500–1700 m a.s.l. spread along the Song Da River (Black River) from the Chinese border to the Pacific coast. Narrow canyons or very deep river valleys separate these plateaux and ridges. This zone of Devonian and Triassic limestone within the peripheral areas of these plateaux appears as a spectacular area of highly eroded karst topography such as that found within Lai Chau, Son La, Hoa Binh, Thanh Hoa, Nghe An and Quang Binh Provinces (Schzeglova 1957; Dovzikov *et al.* 1965b; Rundel 1999).

3.3. Truong Son Range Geomorphologic Region

The Truong Son, or Annamite Range, in its broadest sense extends for nearly 1200 km from north to south along the Vietnamese border with Laos and Cambodia and includes the southern plateau areas of southern Vietnam. This range is complicated in structure resulting from a long history of multiple folding of marine sediments and metamorphic rock, uplifted basement rock, and later volcanic activity with extensive basalt flows.

The main uplift of the Truong Son Range occurred during the Indosinian Orogenies of the late Paleozoic and early Mesozoic. The major portion of the range is composed of deformed Paleozoic marine sedimentary rocks and late Paleozoic — early Mesozoic granite intrusives. The highest point of this mountain system (Xai Lai Leng peak, 2711 m a.s.l.) is situated on the Vietnam – Laos border in the northern part of the ridge. Like the other highest peaks of this area such as Phu Hoat (2452 m), Rao Co (2235 m) and Muong Tip (2040 m) this mountain is composed of Triassic granite (Dovzikov *et al.* 1965b).

The northern part of the Truong Son Range within the narrowest part of Vietnam and to the south of the town of Vinh is relatively low with the highest peaks reaching above 1300 m and within some passes below 500 m a.s.l. These ancient eroded mountains, produced during the Hercynian Foldings and covered by thick continental sandstones of late Triassic age, are rich in early plant fossils and occur in a belt extending from Laos across central Vietnam to around Hoi An to the south of Da Nang (Schzeglova 1957; Rundel 1999). Large areas of this range are covered by highly metamorphosed marine limestone sediments mainly of Devonian, Carboniferous and Permian age and are abundant in marine fossils. The main belt of these deposits crosses the Truong Son Range and extends into Laos in a northwest direction beginning on the coastline. Erosion along the eastern margin of these limestone plateaux produced a spectacular landscape with numerous crowded narrow ridges and mesas towering over a flat alluvial valley to the north-west of Vinh and to the west of Dong Hoi towns (Dovzikov *et al.* 1965a, b).

The south portion of Truong Son Range is primarily an ancient crystalline platform composed of Precambrian gneiss. During the Paleozoic and early Mesozoic orogenic movements, this solid platform was not folded, but rather dissected into a number of blocks uplifted into separate plateaux of varying elevations. The highest of such blocks of southern Vietnam, such as the Kon Tum and Lam Vien (Dalat) plateaux, have elevations of 1000–1500 m a.s.l. Other plateaux, like Playcu, Dac Lac, Mo Nong (Djiring) and others have elevations of only 100–770 m a.s.l. The southern plateaux appear as a mosaic complex composed of late Paleozoic and early Mesozoic granite intrusives and wide fields of Tertiary and Quaternary volcanic effusives that usually cover ancient basement rocks. Scattered areas of granite outcrops and chains of highly eroded volcanic cones are also present on some plateaux (Schzeglova 1957; Rundel 1999).

The Truong Son Range joins the large Kon Tum Massif to the north of Da Nang town. This large plateau of basement parent rock extends approximately 250 km to the south and inland for 200 km. Granite Ngoc Linh peak (2598 m) at the northern margin of the Kon Tum Massif is the highest point of the Truong Son Range in central Vietnam. Chu Dang Sin (2405 m) and Bi Dup (2287 m) peaks, the highest points of the southern highland portion of the Truong Son Range, are also composed of granite. Two significant and heavily eroded peaks occur on the Lam Vien (Dalat) plateau and are composed of various schists and quartzites with extensive areas of granites, volcanic rhyolites, andesites and dacites. The central portions of the Lam Vien (Dalat) highlands are dominated by dacites, including Lang Bian peak reaching 2163 m (Rundel 1999).

Prior to the formation and uplift of the southern Truong Son Range, extensive lava flows in the late Tertiary and Quaternary levelled large plateaux of resistant basalt including Playcu, Dac Lac, Mo Nong (Djiring), Lam Vien (Dalat) and other plateaux in the South. The predominant elevations of these plateaux are 200–700 m a.s.l. The Dac Lac and Pleiku Plateaux, along with Lam Vien (Dalat) plateau, are sometimes referred to collectively as the Taynguyen Plateau.

The Da Rang River and Cheo Reo Depression bound the Pleiku Plateau to the north by the granite Kon Tum Massif, and to the east with extensive alluvial plains at an elevation of approximately 150 m a.s.l. The basaltic soils of the Dac Lac Plateau are most weathered and deepest to the south and shallower to the north, while the soils along the western margin of the Pleiku Plateau are deep and rich (Rundel 1999).

The relatively low plateaux at the extreme southern portion of the Truong Son Range represent a peneplain of levelled Hercynian Folding of old schist and sandstone and largely overlain by basalts of various ages. The older basalts occur to the north and younger basalts to the south. Scattered areas of granite outcrops are also present. Predominant elevations here are 300–600 m a.s.l. However, extensive rolling hills to the southeast, with occasional elevations of 1000–1600 m, of weathered granites are seen as a terraced region stepping down to the Mekong delta and mark the southern margin of Truong Son Range.

It is remarkable that in southern portions of Vietnam, hydrologic drainage flows largely to the west toward Cambodia, isolating river valleys from the more impacted eastern slopes in Vietnam. The very steep east slopes of the Truong Son Range result from an extensive geological fault that split the solid crystalline blocks of ancient plateaux during the late Triassic age about 200 million years ago. At this time the western portion of the Indosinia segment of continental crust experienced uplift while the eastern part of the Sundaland prong of the Eurasian Plate subsided and formed the continental sea shelf separating the Indochina Peninsula and Kalimantan. In some places this fault represents vertical cliffs more than 1000 m high. This area is characterized by narrow, highly eroded canyons of ancient eroded crystalline rocks (mainly granite and gneiss) and abundant waterfalls. The rivers of the eastern slope of the Truong Son Range are rather short and rapidly draining.

3.4. Coastal plains

Irregular coastal plains with low elevations connect the fertile river valleys of northern and southern Vietnam by a narrow belt ending at the coast. The width of the coastal plain in some places is 50 km, but usually much narrower. In some places, for example near Ngang, Chan May and Nai Capes, mountainous extensions of the Truong Son Range interrupt the coastal plain near the sea and appear as steep rocky coastal cliffs.

The hilly parts of the coastal plain adjacent to the mountains are formed of Quaternary alluvium deposited from the Truong Son Range. Old highly eroded sea terraces can be observed here. Along the coast the youngest sea terraces are composed mainly of stabilized sand deposits and dunes of varying Quaternary age.

3.5. Alluvial Valleys of Me Cong and Song Hong River

The two largest rivers of South-East Asia — the Song Hong (Red River) and Me Cong rivers have created wide alluvial delta regions in Vietnam. Both these rivers have wide and largely flat delta plains at low elevations covered by river alluvial deposits of Quaternary age.

The delta lowlands of the Song Hong River (or Bac Bo Lowland) encompass more than 15000 square km. Much of this area is at between only 2–6 m a.s.l. and in some places lies below sea level. The Song Hong River carries a great amount of loess and silt (about 80 million cubic m annually) and raises the delta margin nearly 100 m each year (Schzeglova 1957).

The delta region of the Me Cong, or Nam Bo Lowland, extending over 40500 square km, covers much of the lowlands of southern Vietnam. This uniformly flat, swampy plain has predominant elevations of only 2 m a.s.l. Alluvial materials carried by the Me Cong flow predominantly in a southwest direction. Maximum yearly growth of the coastal territory (about 60–80 m each year) is observed at Ca Mau Cape (Schzeglova 1957).

Rich alluvial soils in each of the delta regions have allowed these areas to evolve as major population centres based on their agricultural productivity. More than 80% of people in Vietnam

live on lands of the coastal and delta plains, while the mountain regions still have very sparse human population.

4. Climate

Winter and summer monsoons are the main factors determining the climate formation within South-East Asia and in Indochina Peninsula. Winds from north and northeast dominate in the region from October to March due to high pressure regularly occurring during the winter period in the centre of Asia over the plains of Mongolia and Siberia. Basically these winds are cold and dry. Mostly they bring to Vietnam cool dry weather. Winds from south and southwest dominate in South-East Asia from April to September. These winds come from the Indian and Pacific oceans where high-pressure regions are formed during summer. Basically summer monsoon winds are warm and wet. They bring hot and rainy weather (Schzeglova 1957; Fridland 1961; Pham Ngoc Toan & Phan Tat Dac 1993). At the same time the complicated orography of the region and specific configuration of the coast line of Vietnam locally shift the direction of monsoon winds, change the times of the dry and rainy seasons and influence the amount of precipitation. Finally this results in the formation of diverse climatic patterns in the country.

Recent climatologic studies (Nguyen Khanh Van *et al.* 2000) have defined seven main types of climate in Vietnam, based on earlier investigations and accumulated climatological data within the region (Walter & Leith 1960–1967; Gaussen *et al.* 1967; Schmid 1974; Thai Van Trung 1978; Hydro-Meteorological Data 1989, 1997; Pham Ngoc Toan & Phan Tat Dac 1993). These types are classified as:

1. Monsoon tropical climate with cold winter and summer rains;
2. Monsoon tropical climate with cold winter and summer-autumn rains;
3. Monsoon tropical climate with warm winter and winter-autumn-winter rains;
4. Monsoon tropical climate with warm winter and autumn-winter rains;
5. Monsoon tropical climate with warm winter and summer rains;
6. Monsoon sub-equatorial climate with summer rains;
7. Monsoon tropical climate associated with mountains.

The climatologic regions of Vietnam are shown in Fig. 1. On this figure the most typical climate diagrams for each region are also presented. A rainfall map of Vietnam compiled from available data of Bruzon & Carton 1930; Chevey & Carton 1935; Schzeglova 1957; Fridland 1961; Walter & Leith 1960–1967; Gaussen *et al.* 1967; Pham Ngoc Toan & Phan Tat Dac 1993; Nguyen Khanh Van *et al.* 2000 is presented in Fig. 2.

4.1. Region of monsoon tropical climate with cold winter and summer rains

This region extends over most of northern Vietnam (Fig. 1). Dry winters with a drought period of 2–5 months extending from December to February or March are most typical of the plains and low mountain regions of northern Vietnam. At the same time in a number of mountain regions, such as Tam Dao Ridge (21°27' N, 105°38' E), Sin Ho (22°21' N, 103°15' E) and Mong Cai (21°31' N, 107°58' E) no dry periods are observed. In other areas the dry season may be very short (Nguyen Khanh Van *et al.* 2000).

Summers in the region are wet, with peak rainfall in July and August. Hanoi has a mean annual rainfall of 1674 mm close to the mean annual rainfall for the region averaged at about 1700 mm. Mean annual precipitation increases up to 2500–2800 mm on south and southeast slopes of large mountain systems such as measured on Tam Dao Ridge and near Tam Duong (22°25' N, 103°29' E), Mong Cai and Sin Ho townlets (Fig. 2). In rather isolated area of Bac Quang town (22°29' N, 104°52' E) mean annual rainfall is exceptionally high at 4802 mm (Nguyen Khanh Van *et al.* 2000). In coastal regions and on north- and northwest-facing mountain slopes minimum rainfall is observed. The mean annual precipitation in areas such as in the towns of Song Ma (21°04' N,

103°44' E), Yen Chau (21°03' N, 104°17' E), Bao Lac (22°57' N, 105°40' E) or Truong Duong (19°17' N, 104°26' E) is often only 1200–1400 mm. Minimum rainfall of 1126 mm has been reported for Bach Long Vi island (20°08' N, 107°43' E) in the centre of Bac Bo (Tonkin) Gulf (Nguyen Khanh Van *et al.* 2000).

Temperature regimes in the north of Vietnam have a strong seasonality. In Hanoi winter conditions with cool temperatures extend from November to April with normal lows of 14–16° C (absolute minimum 2.7° C). Persistent drizzling rains, so called – *craschen*, are very typical of the lowland plains of the region from early February until the end of March. Summers are hot and humid, with maximum temperatures in Hanoi reaching to 33° C (absolute maximum 42.8° C). The mean annual temperature at Hanoi is 23.5° C (Gaussen *et al.* 1967; Rundel 1999; Nguyen Khanh Van *et al.* 2000). The high mountains of northern Vietnam experience cooler temperatures and higher levels of mean annual rainfall with increasing elevation. At elevations above 1000 m a.s.l. hoarfrost is sometimes observed in open places during winter months.

4.2. Region of monsoon tropical climate with cold winter and summer–autumn rains

Temperatures and rainfall amounts of climatic types within this region including the northern part of central Vietnam (Fig. 1) are similar to those described above. The town of Vinh (18°40' N, 105°40' E), for example, has a mean annual rainfall similar to Hanoi's, with 1968 mm. However mean annual precipitation for the region is often high, to 2342 mm. According to available data the amount of annual rainfall varies between 1707 and 3205 mm (Fig. 2). At the same time the timing of rainfall in this region is shifted to earlier in the year, to September and October. Within this region each month receives at least 50 mm of rainfall. Only a few regions, as near the towns of Khe Sanh (16°38' N, 106°50' E) or Do Luong (18°54' N, 105°18' E), experience a distinct dry winter season lasting 2–4 months.

In the region summer temperatures often reach 30–35° C with maximum temperatures recorded to 41–42° C. In winter temperatures normally fall to 14–16° C with absolute minimum recorded to 3–4° C and even 0.7° C reported from Huong Son town (18°27' N, 105°16' E).

4.3. Region of monsoon tropical climate with warm winter and summer–autumn–winter rains

This pattern of climate is common along the coastal zone of central Vietnam (Fig. 1). Within this region rainfall typically occurs in two peaks; one in the summer and one in late autumn, with a distinct break between the two seasons. The pronounced wet season here extends from September through January. Total rainfall increases southward along the coastline with 2936 mm at Hue town (16°24' N, 107°41' E), but dramatically drops to 2041 mm at Da Nang (16°02' N, 108°11' E) and 2003 mm at Hoai Nhon (14°32' N, 109°01' E). Annual precipitation reaches maximum amounts in areas along the eastern slopes of the Truong Son Range (Fig. 2) with up to 3340 mm at the townlets of Ba To (14°46' N, 108°43' E) and 3973 mm near Tra My (15°21' N, 108°13' E).

Within the region there is usually a semi-dry season lasting from 2–4 months from February to April or May. In some places, like Hue, Tra My and Dong Hoi (17°28' N, 106°37' E), significant rainfall of 20–50 mm falling in all of these months has been recorded without a distinct dry season (Gaussen *et al.* 1967; Nguyen Khanh Van *et al.* 2000).

Summer in the region is hot with usual temperatures reaching 30–34° C (with absolute maximum 40–42° C). Winters are warm with mean temperatures about 18–22° C, rarely falling below 18° C. An absolute minimum temperature of 4.5° C has been reported from Con Co Island (17°10' N, 107°22' E).

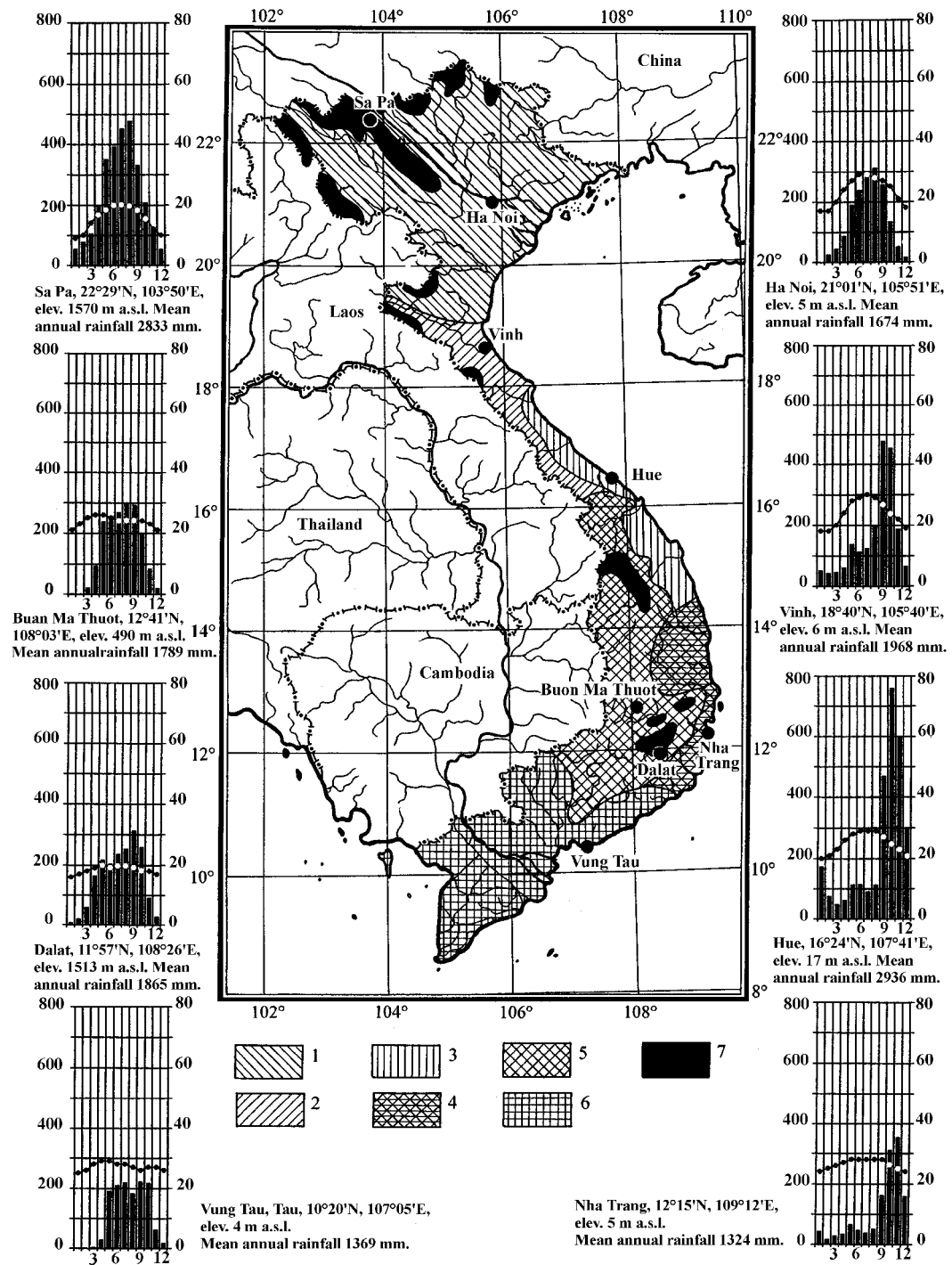


Fig. 1. The seven climatological regions of Vietnam and typical climatic diagrams specific for these regions (compiled from Nguyen Khanh Van *et al.* 2000). Explanations are given in the text.

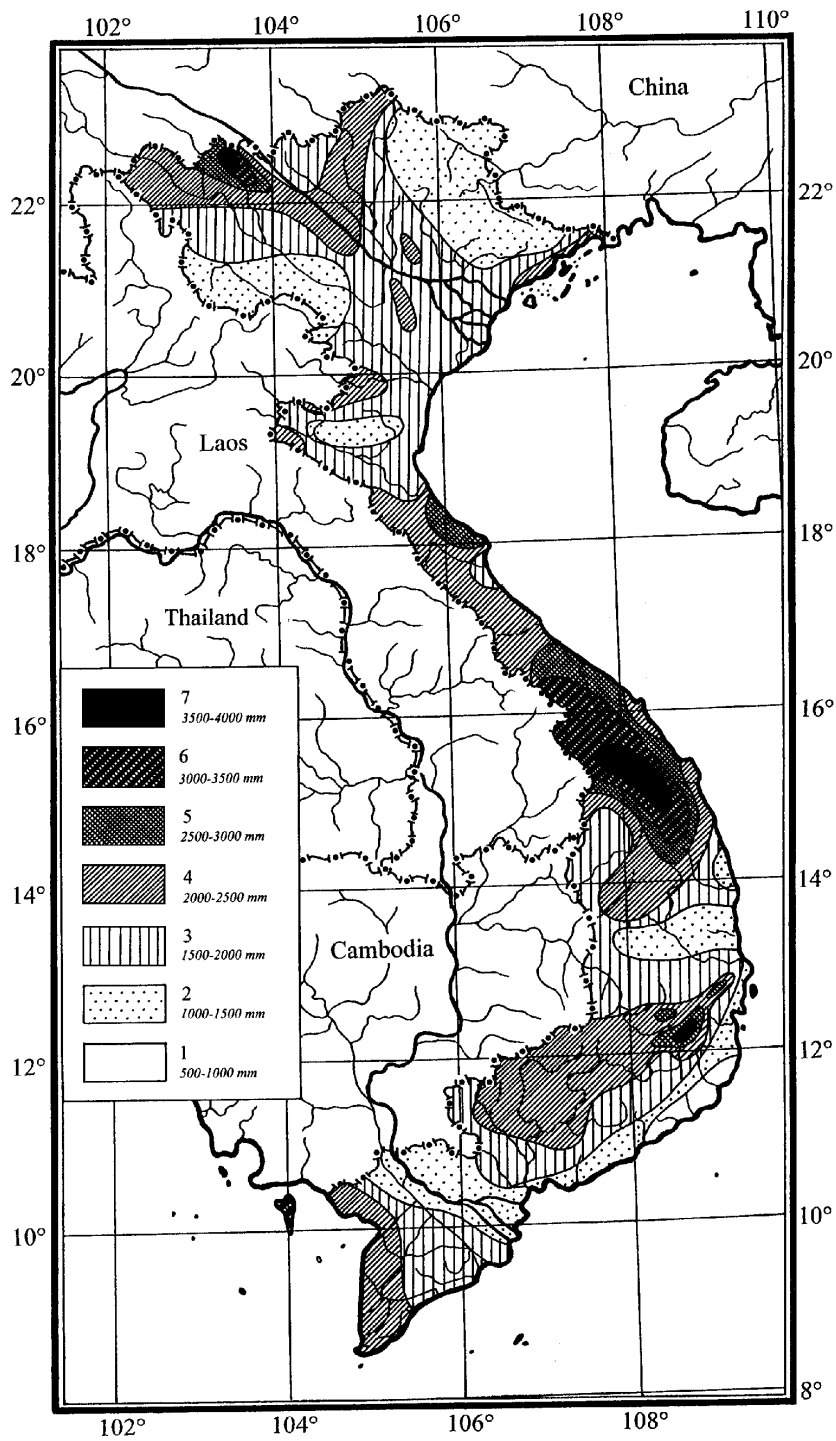


Fig. 2. Rainfall map of Vietnam (compiled from Bruzon & Carton 1930; Chevey & Carton 1935; Schzeglova 1957; Fridland 1961; Walter & Leith 1960–1967; Gaussen *et al.* 1967; Pham Ngoc Toan & Phan Tat Dac 1993; Nguyen Khanh Van *et al.* 2000).

4.4. Region of monsoon tropical climate with warm winter and autumn–winter rains

This climatic pattern is observed along coastal areas in the northern portion of southern Vietnam (Fig. 1). Maximum rainfall in this region falls typically in October and November, brought in by the northeastern monsoon winds. This region is the most arid within the Indochinese Peninsula with a semi-desert climate characterizing the coastal zone from the town of Quy Nhon (13°46' N, 109°13' E) southward to Phan Thiet town (10°56' N, 108°06' E). Most of this region lies within the rain shadow of the southern Truong Son Range, producing a mean annual rainfall of less than 1500 mm (Fig. 2), and a dry season lasting up to nine months (Bruzon & Carton 1930; Schzeglova 1957).

The driest part of the region spreads along the coast from Phan Rang to Phan Thiet (Fig. 2). Ca Na (Padaran) Cape (11°18' N, 108°55' E) south of Phan Rang receives only 757 mm of rainfall annually with a recorded minimum of 409 mm (Bruzon & Carton 1930; Schzeglova 1957; Schmid 1974). Three-year observations in Phan Ri (11°08' N, 108°33' E), Mui Ne (10°53' N, 108°17' E) and Phan Rang (11°33' N, 108°59' E) respectively recorded 622 mm, 596 mm and 413 mm of mean annual precipitation (Bruzon & Carton 1930; Schzeglova 1957). These regions experience a second summer drought period in July and August when air currents bringing monsoon rains are blocked. Rainfall within the coastal belt is highly variable between years and monthly totals are less than 100 mm for 6–9 months each year.

In the northern areas of this climatic region (including the Song Ba Valley and Cho Reo Depression) the amount of rainfall increases along an east–west transect from the coast inland. Mean annual precipitation of 1697 mm in Quy Nhon (13°46' N, 109°13' E) and 1715 mm in Son Hoa (13°03' N, 108°59' E) townlets have been recorded. These areas are semi-arid experiencing a distinct dry period lasting 2–5 months.

The temperature regimes within this region are similar to sub-equatorial areas. Mean annual temperatures are 25–26° C. Normal winter temperatures in the region range from 20–25° C, with some stations recording absolute temperature minimums of 12–14° C. Normal summer temperatures are 28–29° C with rare occurrences of up to 38–42° C.

4.5. Region of monsoon tropical climate with warm winter and summer rains

This climatic region is a hot, semi-humid zone, characterized by moderate levels of rainfall between 1500 mm at Yok Don Nature Reserve (13°00' N, 107°30' E) and 2339 mm in Dac Nong town (12°00' N, 107°41' E). Most of the annual precipitation falls in the summer (Fig. 2). This semi-humid climate dominates more than half of southern Vietnam, including the majority of lowland and middle elevation areas below 800–1000 m (Fig. 1). In winter there are typically 3–4 months with less than 50 mm rainfall. However in some places, like in the townlets of Bao Loc (11°28' N, 107°48' E) and Nam Dong (16°09' N, 107°43' E), the dry period may be very short. Condensation as dew is frequent in the dry season, but fog is rare.

Mean annual temperatures in the region are 22–25° C. Normal summer temperatures are common between 22–27° C with winter temperatures 19–25° C. An absolute temperature maximum of 41° C has been reported in Nam Dong. An absolute minimum of 3.4° C has been recorded in Dac To (14°42' N, 107°49' E) at an elevation of 620 m a.s.l.

In montane areas of this region the peak months for rainfall are usually August to October and are under the influence of the southward return of the monsoon with northeastern winds. The humid submontane climate of this zone is experienced in upland areas at middle elevations below about 1100 m that are exposed to humid winds. Mean annual rainfall here is generally above 2500 mm and quite regular, with brief dry seasons lasting three months or less. Dew is frequent during the brief dry season and foggy mists are common. This climatic zone covers mainly the hill and mountain areas of Kon Tum, Dac Lac and Mo Nong Plateaux.

4.6. Region of monsoon sub-equatorial climate with summer rains

In the southern lowland areas of Vietnam distinct wet and dry periods are evident and temperatures are higher than anywhere else in the country. This zone experiences a hot monsoon sub-equatorial climate (Fig. 1).

Minimum amounts of annual precipitation are observed in the area along the eastern seacoast and in the inland plain districts. Mean annual rainfall ranges from 1086 mm in Phan Thiet (10°56' N, 108°06' E) to 1297 mm in Chau Doc (10°46' N, 105°08' E), 1359 mm in Cao Lanh (10°28' N, 105°38' E) and 1369 mm in Vung Tau (10°20' N, 107°05' E) towns (Fig. 2). The dry season in these semi-arid areas is observed in winter and can last from 4 to 6 months.

Annual precipitation increases considerably in areas of southern Vietnam situated along the western seacoast on the Gulf of Thailand and in districts near to the southwest slopes of the southern extensions of the Truong Son Range. In these areas annual precipitation may reach 2109 mm in Rach Gia (10°00' N, 105°05' E), 2344 mm in Ca Mau (9°10' N, 105°10' E) and 2469 mm in Dong Phu (11°32' N, 106°54' E) towns (Fig. 2). There is also a distinct dry period recorded for these areas.

Considerable amounts of annual rainfall and a distinct dry period are typical of some islands of southern Vietnam such as Phu Quoc (10°13' N, 103°58' E) and Con Dao (8°41' N, 106°36' E), and as far away as Truong Sa atoll archipelago (8°39' N, 111°55' E). These territories have recorded 3024 mm, 2069 mm and 2388 mm of mean annual rainfall, respectively. On the contrary, the small islands situated near the southeastern shore of Vietnam including Cu Lao island (10°31' N, 108°56' E) receive comparatively little rain, recorded as 1244 mm annual precipitation.

Mean annual temperatures throughout the year vary between 25–29° C. Winter and summer temperatures do not differ more than 2–3° C, which is very typical of a sub-equatorial climate. An absolute temperature minimum of 11.9° C has been reported from Dong Phu town area at 89 m a.s.l., and maximum temperatures of 40° C was observed in Tan Son Nhat (10°49' N, 106°40' E) and Can Tho (10°02' N, 105°47' E) cities.

4.7. Region of monsoon tropical climate associated with mountains

In Vietnam a monsoon tropical climate associated with montane areas is typical of areas higher 1400–1500 m a.s.l. Such regions spread along the largest mountain ranges of northern Vietnam including the Hoang Lien Son, Si Lung, Den Dinh and Sam Sao ranges. This climate is also experienced in the highland areas of some of the more isolated mountain systems like Tay Con Linh, Pu Tha Ca, Pia Da and Pia Oac. In the south of the country this climatic type associated with mountains occurs in the highlands of Kon Tum and Lam Vien (Dalat) Plateaux (Fig. 1). Mean annual precipitation rates recorded from mountain regions of northern Vietnam include 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.). The peak of rainfall here is during the summer months. Typically these areas experience no dry period.

In the southern Vietnam, specifically from the Dalat town station (11°57' N, 108°26' E, elev. 1513 m a.s.l.) the mean annual rainfall is 1865 mm, with a summer rain peak and 1–2 months dry winter period of less than 50 mm rainfall. At the same time on the eastern margin of the Lam Vien Plateau at Hon Ba station (12°05' N, 108°45' E, elev. 1480 m a.s.l.), very heavy rains of 3851 mm occur with no dry month (Schmid 1974). Rainfall is concentrated very late in November and is under the influence of the moisture-bearing northeastern monsoon winds.

Morning condensation as dew and frequent heavy foggy mists are very common throughout the mountainous zone. In general, humidity and rainfall amounts increase along with elevation in any mountain area in Vietnam.

Temperatures are normally influenced by elevation. Mean annual temperature in Sa Pa at elev. 1570 m a.s.l. is 15.2° C, while in Hoang Lien Son at elev. 2170 m a.s.l. it is 12.8° C. Summer temperatures in these regions are usually 16–20° C and winter mean temperatures are regularly between 7–10° C. Absolute minimum temperature reported at 2170 m a.s.l. is –5.7° C. Snow, sleet and hail commonly mixed with rain are frequent here during the winter months. The maximum temperature recorded at this elevation is 24.9° C.

Records from the Dalat and Hon Ba stations in the southern Vietnam have recorded mean annual temperatures of 18.2° C and 17.4° C respectively. Mean temperatures in this area in summer are around 19–20° C, with winter temperatures near 14–18° C. The maximum temperature recorded at Dalat town is 31.5° C and minimum reported temperature –0.1° C. In highland areas of Ngok Linh of the Kon Tum Massif ice and winter night frost have been recorded from between of 1700–1800 m a.s.l.

5. General outline of Vietnamese flora

Our knowledge of the flora of Vietnam is still far from satisfactory and based on incomplete botanical inventory activities of past decades. However, owing to some fundamental taxonomic publications, such as «Flora Cochinchinensis» (Loureiro 1790, 1794), «Flore Generale de l'Indochine» (Lecomte & Humbert 1907–1951), «Flore du Cambodge, du Laos et du Viet-Nam» organized by Prof. J. E. Vidal (Aubreville *et al.* 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» (Averyanov *et al.* 1990, 1996) and a number of large recent floristic and taxonomical monographs (Schmid 1974, 1989; Averyanov *et al.* 1988; Vu Van Dung 1996; Nguyen Nghia Thin & Harder 1996; Nguyen Tien Ban 1997; Nguyen Nghia Thin 1997a, 1998, 1999; Nguyen Nghia Thin & Nguyen Thi Thoi 1998 and many others) we now have improved knowledge of the richness and diversity of the Vietnamese flora. Many publications have been dedicated solely to the diversity of orchids (*Orchidaceae*), the largest family in the flora of Vietnam (Seidenfaden 1975, 1992; Averyanov 1988a–f, 1989, 1990c–d, 1991, 1994, 1996a–c, 1997a–c, 1998a–b, 1999a–c, 2000a–c; Averyanov & Duong Duc Huyen 1989, 1990, 1993; Averyanov & Vu Ngoc Long 1989, 1990, 1991; Duong Duc Huyen & Averyanov 1989, 1991, 1992; Averyanov *et al.* 1996a–b, 1997a–b, 2000; Averyanov & Christenson 1998a–e; Tran Hop 1998; Averyanov & Averyanova 2000, 2003; Cribb *et al.* 2000).¹

A number of preliminary studies estimated (Tolmachev 1974; Nguyen Nghia Thin 1997b; Phan Ke Loc 1998) the Vietnam flora to contain about 9600 species of vascular plants, but subsequent studies include an additional 2400, to give a total indigenous vascular flora of approximately 12000 species and nearly 2010 genera. Of these about 750 naturalized, introduced and cultivated species in Vietnam represent the adventitious element of the flora. The most recent account estimates there are approximately 10350 species in 2256 genera and 305 families (Phan Ke Loc 1998). Vietnam has a remarkably diverse flora for a relatively small country. The high degree of environmental heterogeneity in Vietnam in climate regime, soil, landscape and topography underlies this high diversity.

The flora of Vietnam is not only large, but also rich in endemic species, adding to its significance. Some preliminary studies (Vo Quy 1995) suggest that about 10% of all species and 3% of genera are endemic to Vietnam. Among the 305 vascular plant families reported for Vietnam the highest levels of endemism are observed in the *Acanthaceae*, *Anacardiaceae*, *Annonaceae*, *Apocynaceae*, *Araceae*, *Arecaceae*, *Asclepiadaceae*, *Celastraceae*, *Ericaceae*, *Euphorbiaceae*, *Fagaceae*, *Myrsinaceae*, *Rubiaceae*, *Sapindaceae*, *Sapotaceae*, *Symplocaceae*, *Theaceae* and *Zingiberaceae* (Schmid 1974; Takhtajan 1986; Rundel 1999). Species endemism

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

within the *Orchidaceae* in the Indochina Peninsula reaches 35%. The level of endemism within the Vietnamese orchid flora is about 19% (Averyanov 1991c).

According to the character and role of the largest families of flowering plants in its systematic structure, the Vietnamese flora is most allied to the floras of the Paleotropic Kingdom (Tolmachev 1974; Phan Ke Loc 1998). The ten largest families in this flora are *Orchidaceae*, *Fabaceae*, *Poaceae*, *Euphorbiaceae*, *Rubiaceae*, *Cyperaceae*, *Asteraceae*, *Lauraceae*, *Fagaceae* and *Acanthaceae* (Table 1). At present about 750 species and 135 genera are reported for the *Orchidaceae* in the flora of Vietnam (Averyanov 1990a, b, d, 1991a, b, e, 1994; Phan Ke Loc 1998).

Table 1. Ten largest families of vascular plants in the flora of Vietnam (Phan Ke Loc 1998)

	Family	Number of species	Percent of the total flora
1	<i>Orchidaceae</i>	753	7.8%
2	<i>Fabaceae</i>	557	5.8%
3	<i>Poaceae</i>	467	4.9%
4	<i>Euphorbiaceae</i>	416	4.3%
5	<i>Rubiaceae</i>	395	4.1%
6	<i>Cyperaceae</i>	304	3.2%
7	<i>Asteraceae</i>	291	3.0%
8	<i>Lauraceae</i>	245	2.5%
9	<i>Fagaceae</i>	211	2.2%
10	<i>Acanthaceae</i>	177	1.8%

More or less comprehensive modern data on the Vietnamese flora are available for the *Orchidaceae* allowing an appropriate florogenetic analysis of this group of plants to be made. Data obtained for this the largest family may be extrapolated to the whole flora of the region.

About 3% of the known Vietnamese orchids have a wide intercontinental distribution (pantropical, paleotropical and Australasian species). About 3.6% have a wide distribution within mainland Asia and Malesia. Nearly 6.9% of the species are distributed from the eastern Himalayas and South-East Asia to West Malesia. Eleven percent of the species are distributed in the Indochinese Peninsula and West Malesia, and 73% of Vietnamese orchids have a continental distribution in mainland South-East Asia. Among this last group of orchids, about 16% of Vietnamese orchids are endemic to the Indochinese Peninsula and 19.2% are endemic to Vietnam (Averyanov 1991c, 1999b). The florogenetic groups of orchids and their proportions in the Vietnamese orchid flora are presented in table 2. The orchid flora of Vietnam shows close relationships to the floras of tropical mainland Asia. This may well be true for entire flora of Vietnam.

Table 2. Distribution and proportion types of orchid groups with distribution patterns in the orchid flora of Vietnam (Averyanov 1991c)

	Distribution types	Approximate portion in the Vietnamese orchid flora
1	Pantropical	0.3%
2	Paleotropical	0.4%
3	Asian-Australian	2.4%
4	Asian	96.9%
4.1	South-Asian group	3.7%
4.1.1	South-Asia-Malesian	1.3%
4.1.2	South-Asia-Sundaic	2.4%
4.2	E Himalayan-SE Asian group	8.8%

4.2.1	E Himalayan-Malesian	2.0%
4.2.2	E Himalayan-Sundaic	2.5%
4.2.3	E Himalayan-Sumatra-Borneo-Philippinean	0.6%
4.2.4	E Himalayan-Sumatra-Java-Philippines	1.0%
4.2.5	Himalayan-Borneo-Philippines	0.1%
4.2.6	E Himalayan-Sumatra-Javanese	0.8%
4.2.7	E Himalayan-Sumatranian	0.4%
4.2.8	E Himalayan-Bornean	0.1%
4.2.9	E Himalayan-Philippines	1.3%
4.3	Indochina-Malesian group	11.0%
4.3.1	Indochina-Malesian	1.8%
4.3.2	Indochina-Sundaic-Philippines	0.8%
4.3.3	Indochina-Sundaic	1.8%
4.3.4	Indochina-Java-Borneo-Philippines	0.3%
4.3.5	Indochina-Java-Sumatranian	1.4%
4.3.6	Indochina-Borneo-Sumatranian	0.8%
4.3.7	Indochina-Borneo-Philippines	0.1%
4.3.8	Indochina-Sumatranian	1.1%
4.3.9	Indochina-Javanese	0.8%
4.3.10	Indochina-Bornean	0.8%
4.3.11	Indochina-Philippines	1.0%
4.4	SE Asia mainland group	73.4%
4.4.1	SE Asia mainland	2.8%
4.4.2	Hindustan-Indochinese	1.4%
4.4.3	E Himalayan-SE Asian (mainland)	1.1%
4.4.4	E Himalayan-S Chinese	5.3%
4.4.5	S Chinese	4.2%
4.4.6	E Himalayan-Indochinese	23.5%
4.4.7	Malay-Indochinese (mainland)	4.9%
4.4.8	Indochinese (except Malay Peninsula)	11.0%
4.4.9	Vietnamese	19.2%

The ten largest genera of orchids in the orchid flora of Vietnam are presented in Table 3. They represent the typical spectrum of the largest orchid genera in other orchid floras of tropical Asia. However the appearance of *Paphiopedilum* in the set of ten largest genera in the orchid flora is remarkable and unique. This fact characterizes the Vietnamese orchid flora as one of the richest floras of the world in *Paphiopedilum* species, all of which are of outstanding significance in horticulture.

Table 3. The ten largest orchid genera in the flora of Vietnam (Averyanov 1991c)

	Genus	Number of species	Percent of the total orchid flora
1	<i>Dendrobium</i>	97	12.9%
2	<i>Bulbophyllum</i>	78	10.4%
3	<i>Eria</i>	37	4.9%
4	<i>Habenaria</i>	27	3.6%
5	<i>Coelogyne</i>	25	3.3%
6	<i>Liparis</i>	25	3.3%
7	<i>Oberonia</i>	24	3.2%
8	<i>Cleisostoma</i>	20	2.7%
9	<i>Calanthe</i>	18	2.4%
10	<i>Paphiopedilum</i>	17	2.3%

The most numerous endemic orchid species in the Vietnamese flora are reported in such genera as *Anoectochilus*, *Bulbophyllum*, *Calanthe*, *Cheirostylis*, *Cleisostoma*, *Coelogyne*, *Cymbidium*, *Dendrobium*, *Eria*, *Liparis*, *Oberonia*, *Paphiopedilum*, *Pholidota* and *Taeniophyllum* (Averyanov 1991c). Five monotypic orchid genera — *Christensonia*, *Diceptor*, *Cleisostomopsis*, *Eparmatostigma* and *Vietorchis* — are reported as endemic to Vietnam. The first four of these genera, however, are not significantly different from large polymorphic genera — *Aerides*, *Acampe*, *Cleisostoma* and *Malleola* — respectively.

6. Main patterns of vegetation in Vietnam

Monsoon tropical forests are the most typical vegetation of the eastern Indochinese Peninsula and Vietnam. Wet closed evergreen broad-leaved, mixed or coniferous forests are present in mountainous regions. In some hilly lowland and valley areas with more arid conditions these forests give way to open semi-deciduous and deciduous broad-leaved forest, woodlands and semi-savannas. Along semi-desert coastal plains and on seasonally drier sea slopes of southern Vietnam, such woodlands develop shrubby derivatives, which often appear as more or less dense sclerophytic scrub. Swampy grass-sedge communities and mangrove thickets are very common on flat coastal plains and are especially well developed within the deltas of large rivers. At present all types of native primary vegetation are adversely affected by human activity and most are completely converted over most of the country. Secondary forests, scrubs and grasslands, bamboo thickets, tree plantations, pastures, crop and vegetable fields and various weed communities usually lacking all native plants now replace native vegetation over vast areas of the territory. A simplified vegetation map of Vietnam is presented in figure 3 with the 8 major types of plant communities roughly outlined.

6.1. Evergreen broad-leaved lowland forests on alkaline soils

Originally these forests covered more or less eroded hilly limestone plateaux and flat bottoms of alluvial valleys. The alkaline soils are associated with basement sedimentary rocks rich in calcite or magnesite minerals. In prehistoric ages they covered large areas of modern Vietnam from sea level up to about 1000 m a.s.l. At present these forests are almost completely destroyed over most of their original areas. Last remaining remnants may rarely be observed in few areas of the country on plains and slopes of limestone plateaux or on terraces of river valleys. Sometimes remnants of such forests survive along rivers and appear as fragments of gallery woods on flat deforested river valleys (Fig. 3).

A humid and rainy summer during May–October and a dry winter with moderate temperatures from October up to April are typical of the area of the broad-leaved lowland forests. A very humid period of heavy fogs and drizzling rains is observed in these regions in March–April. Rainfall and temperature regimes on plains of limestone areas of northern Vietnam are similar to those of the area around Hanoi (Fig. 1).

At low elevations valleys of primary evergreen broad-leaved forests on alkaline soils are usually wet and highly closed. The tallest trees of the upper forest stratum regularly reach 30–35 m high. The dominant canopy trees in forests of this type are mostly representatives of tropical families (Nguyen Nghia Thin 1994, 1997a) such as:

<i>Anacardiaceae</i> (<i>Choerospondias</i> , <i>Dracontomelon</i>),	<i>Fabaceae</i> (<i>Erythrophleum</i> , <i>Paralbizzia</i> , <i>Saraca</i>),
<i>Clusiaceae</i> (<i>Garcinia</i>),	<i>Lauraceae</i> (<i>Caryodaphnopsis</i> , <i>Cinnamomum</i> , <i>Phoebe</i>),
<i>Combretaceae</i> (<i>Anogeisus</i> , <i>Terminalia</i>),	<i>Meliaceae</i> (<i>Aglaia</i> , <i>Chisocheton</i>),
<i>Datiaceae</i> (<i>Tetrameles</i>),	<i>Moraceae</i> (<i>Streblus</i> , <i>Ficus</i>),
<i>Dipterocarpaceae</i> (<i>Parashorea</i> , <i>Vatica</i>),	<i>Sapindaceae</i> (<i>Pometia</i>),
<i>Ebenaceae</i> (<i>Diospyros</i>),	

Sapotaceae (Madhuca),
Simaroubaceae (Canarium),
Sterculiaceae (Pterospermum, Sterculia),

Styracaceae (Rehderodendron),
Tiliaceae (Burretiodendron).

Termophilous trees in the *Hamamelidaceae* such as *Symingtonia tonkinensis* and *Liquidambar formosana* as well as some tropical oaks such as *Castanopsis indica*, *Lithocarpus bacgiangensis* and *L. licentii* (*Fagaceae*) are also common dominants in these forests (Rundel 1999). The orchid flora of wet closed evergreen broad-leaved lowland forests on alkaline soils is very rich. Numerous hygrophilous and skiophilous terrestrial orchids inhabit forests of this type. Most typical species among them are:

<i>Calanthe alismifolia,</i>	<i>Erythrodes blumei,</i>	<i>Malaxis acuminata,</i>
<i>C. angusta,</i>	<i>Geodorum attenuatum,</i>	<i>Nervilia fordii,</i>
<i>C. herbacea,</i>	<i>Goodyera foliosa,</i>	<i>Tropidia angulosa,</i>
<i>C. triplicata,</i>	<i>G. fumata,</i>	<i>T. curculigoides,</i>
<i>Corymborkis eratrifolia,</i>	<i>G. hispida,</i>	<i>Vrydagzynea albida,</i>
<i>Cymbidium ensifolium,</i>	<i>Habenaria ciliolaris,</i>	<i>Zeuxine nervosa.</i>
<i>C. lancifolium,</i>	<i>Hetaeria rubens,</i>	
<i>C. sinense,</i>	<i>Liparis nervosa,</i>	

Very primitive representatives of the *Orchidaceae* like *Neuwiedia griffithii* or *N. inae*, and rare local endemics such as *Zeuxine vietnamica* are found in such environments. Some rare interesting achlorophyllous mycotrophic orchids may be also seen here. Among them are *Cyrtosia javanica*, *Didimoplexiopsis khiriwongensis*, *Didymoplexis pallens*, *Epipogium roseum*, *Erythrorchis ochobiensis* and *Vietorchis aurea*. The creeping epiphytic liana, *Vanilla annamica*, with thick fleshy stems can reach 10 m and more long in these forests.

The canopies of large trees also support a rich and diverse epiphytic orchid flora in these forests. The most common epiphytic orchids found in forests developed on alkaline soils in Vietnam are:

<i>Aerides odorata,</i>	<i>Dendrobium acinaciforme,</i>	<i>Eria pannea,</i>
<i>Callostylis rigida,</i>	<i>D. aduncum,</i>	<i>Liparis viridiflora,</i>
<i>Ceratostylis himalaica,</i>	<i>D. anosmum,</i>	<i>Malleola insectifera,</i>
<i>Cleisostoma aspersum,</i>	<i>D. failhaberianum,</i>	<i>Ornithochilus difförmis,</i>
<i>C. fuersteinbergianum,</i>	<i>D. hercoglossum,</i>	<i>Pelatantheria insectifera,</i>
<i>C. rostratum,</i>	<i>D. lindleyi,</i>	<i>Phalaenopsis lobbii,</i>
<i>C. williamsonii,</i>	<i>D. linguella,</i>	<i>Pholidota rubra,</i>
<i>Coelogyne fimbriata,</i>	<i>D. nobile,</i>	<i>Robiquetia succisa,</i>
<i>Cymbidium aloifolium,</i>	<i>D. parishii,</i>	<i>Thrixspermum centipeda,</i>
<i>C. bicolor,</i>	<i>D. wardianum,</i>	<i>Trichotosia dasyphylla.</i>

Among epiphytic species of this zone are some rare local Vietnamese endemics such as *Biermannia calcarata*, *Dendrobium nobile* var. *albolutea*, *Phalaenopsis gibbosa* and *Pteroceras simondianum*.

6.2. Evergreen and semi-deciduous broad-leaved, mixed and coniferous limestone montane forests

Spectacular karst landscapes formed by narrow rocky ridges and numerous crowded column-like mesas with very steep slopes and sheer cliffs are widely distributed in northern Vietnam. Ancient highly eroded karst of solid, marble-like limestone making up such mountains creates very specific soil and environmental conditions supporting a unique flora and vegetation. Tropical evergreen and semi-deciduous, broad-leaved and mixed forests spread across areas of limestone rocky outcrops in Vietnam mainly on elevations from the sea level up to 1600 m a.s.l., although

the main parts of these regions occur between 300–900 m a.s.l. In a number of places within Vietnam narrow strips of deciduous broad-leaved or coniferous forests occur along the highest ridges, sometimes between 1400–1700 m a.s.l. (Fig. 3).

A hot, damp summer with an abundance of precipitation falling as torrential rains occurring from May–June until September–October is typical of these limestone areas of Vietnam. The winters from October until April are dry and rather cool. Mean annual rainfall is between 1000–2500 mm.

Average summer temperatures usually vary between 25–30° C, normal recorded winter temperatures at 200–300 m a.s.l. hover around 15° C. On the coldest winter nights, at 1200–1500 m in relatively open places, hoarfrost and light freezing occasionally occur (Averyanov *et al.* 2000).

The obvious zonal character of the primary vegetation on the limestone mountains of Vietnam may be clearly observed. Evergreen broad-leaved, highly closed and wet forests are usually found in the foothills and on steep slopes of highly eroded, marble-like, karstic limestone ridges. Dominants of the upper forest stratum such as *Burretiodendron hsienmu*, *Gleditchia* sp. and *Symingtonia populnea* reach 25–30 m high and up to 2 m in diam. at breast height in these forests (Averyanov *et al.* 2000). Lower subcanopy and undergrowth strata in these forests are well developed and composed of numerous tree and shrub species from a wide variety of families (Nguyen Nghia Thin 1994, 1997a) such as:

<i>Annonaceae</i> (<i>Mitrephora</i>),	<i>Rosaceae</i> (<i>Eriobotrya</i>),
<i>Clusiaceae</i> (<i>Calophyllum</i>),	<i>Rubiaceae</i> (<i>Canthium</i>),
<i>Ebenaceae</i> (<i>Diospyros</i>),	<i>Rutaceae</i> (<i>Murraya</i>),
<i>Euphorbiaceae</i> (<i>Trigonostemon</i>),	<i>Sapindaceae</i> (<i>Xerospermum</i>),
<i>Moraceae</i> (<i>Dimerocarpus</i> , <i>Ficus</i> , <i>Streblus</i> , <i>Teonongia</i>),	<i>Sapotaceae</i> (<i>Sinosideroxylon</i>),
<i>Oleaceae</i> (<i>Jasminum</i>),	<i>Sterculiaceae</i> (<i>Heritiera</i> , <i>Pterospermum</i>).

On the upper slopes and along the ridge tops, broad-leaved forests are replaced by a rather open, mixed, semi-deciduous but not very tall forest in which conifers are dominant, notably *Pinus kwangtungensis*, *Pseudotsuga brevifolia* and *Tsuga chinensis* (Nguyen Tien Hiep 1998; Phan Ke Loc *et al.* 1999a). Many other gymnosperm trees, like *Amenthotaxus argotaenia*, *Cephalotaxus mannii*, *Cupressus torulosa*, *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Fokienia hodginsii*, *Keteleeria davidiana*, *Nageia fleurii*, *Podocarpus neriifolius*, *P. pilgeri*, *Taxus chinensis* and *Xanthocyparis vietnamensis* are also sometimes found in these forests (Nguyen Tien Hiep 1998; Averyanov *et al.* 2000, 2002). Cycad species, such as *Cycas balansae*, *C. diannanensis*, *C. miquelii*, *C. multifrondis* and *C. taiwaniana* are also sometimes found here from sea level up to 600 m a.s.l. Among the broad-leaved forest dominants the most common are semi-deciduous or deciduous trees. In this group are species of *Acer*, *Alangium*, *Carpinus*, *Lithocarpus*, *Quercus*, *Ulmus* and *Platycarya strobilacea*. In the second forest stratum *Illicium difengpi*, *Pistacia weinmannifolia*, *Schefflera pes-avis*, *Tirpitzia sinensis*, species of *Euonymus*, *Photinia*, *Madhuca* and *Sorbus* are characteristic. The most typical shrubs and small trees here are representatives of *Celastrus*, *Lespedeza*, *Pittosporum*, *Sophora*, *Wikstroemia*, numerous species of *Rhododendron*, *Vaccinium*, and also some species of dwarf palms, such as species of *Guihaia*, *Livistona*, *Licuala* and *Rhapis* (Phan Ke Loc *et al.* 1999a; Averyanov *et al.* 2000).

On limestone mountains above 1200 m a.s.l., especially on isolated peaks and along narrow ridges, open mossy coniferous forests often dominate, with a more or less significant mix of broad-leaved semi-deciduous trees exclusively in the second forest stratum. Numerous herbaceous plants, other than orchids, are commonly found in these mixed and coniferous forests on limestone, including some species of *Ainsliaea* (*Asteraceae*), *Alpinia*, *Hedychium* (*Zingiberaceae*), *Arisaema* (*Araceae*), *Lysimachia* (*Primulaceae*), *Selaginella* (*Selaginellaceae*) and some species of *Begonia* (*Begoniaceae*) with brightly variegated leaves. Species of *Convallariaceae* (including numerous

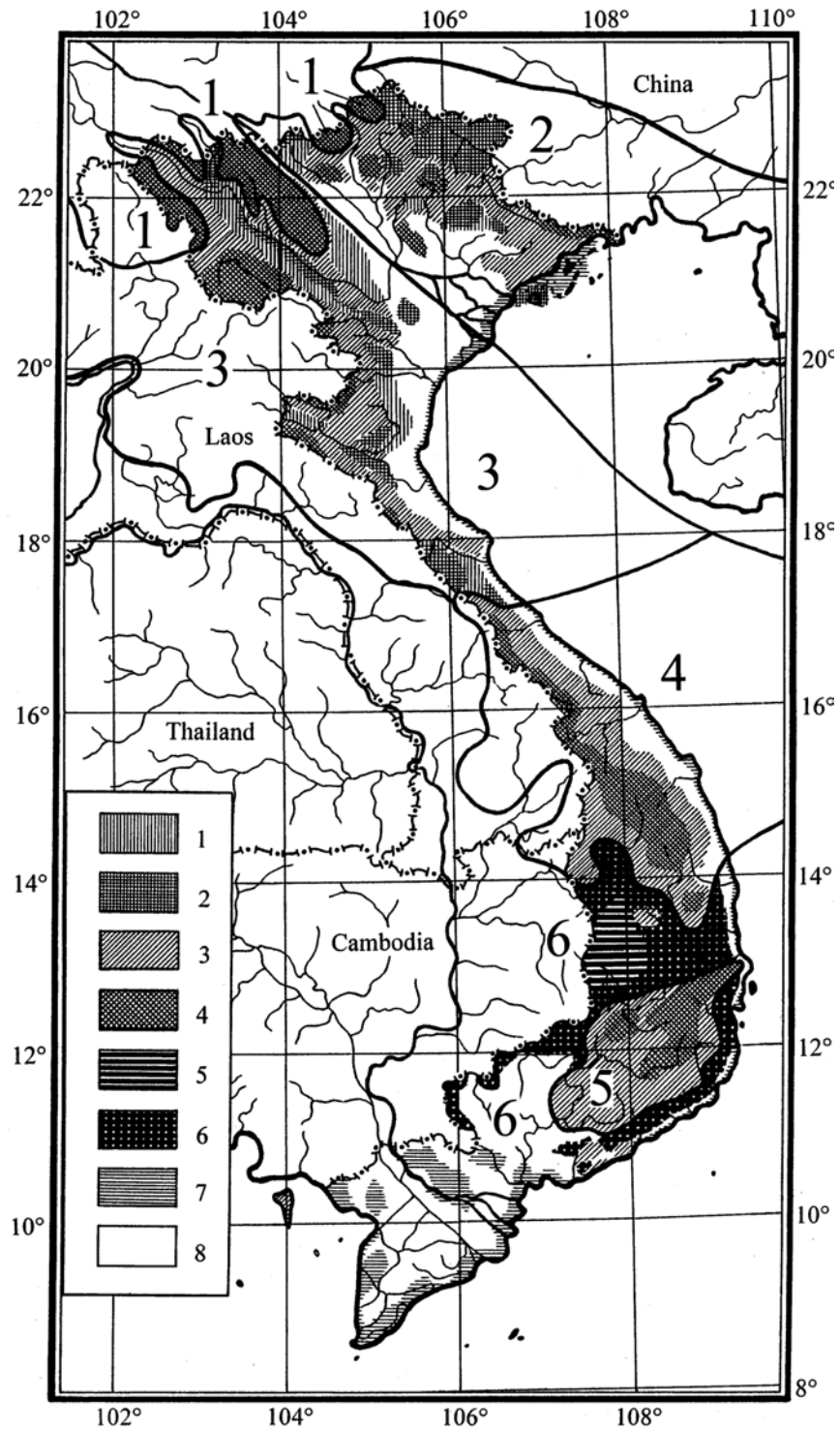


Fig. 3. Main vegetation types in Vietnam and floristic regions of the area.

species of *Aspidistra*, *Disporum*, *Ophiopogon*, *Peliosanthes*, *Polygonatum* and *Tupistra*) and *Urticaceae* (*Elatostema*, *Laportea*, *Pellea* and *Pellionia*) are also well represented. Unusual succulent species of *Impatiens*, many kinds of sedges (*Carex*, *Scleria*), numerous ferns and herbs from *Acanthaceae*, *Gesneriaceae* and *Melastomataceae* also occur in these forests (Phan Ke Loc *et al.* 1999a; Averyanov *et al.* 2000).

Orchids reach their extraordinary abundance and diversity in the primary, light, semi-deciduous, mixed and coniferous woods that spread along the summits of karst limestone ridges. Plentiful light under the canopy of the forest trees supports their abundance on the forest floor.

Some orchids are found on open rocks and bluffs or in shrubby forest undergrowth thickets. Among such species are *Acampe rigida*, *Aerides rosea*, *Cleisostoma paniculatum*, *C. striatum*, *Hygrochilus parishii*, *Flickingeria fimbriata*, *Renanthera coccinea*, *R. vietnamensis*, *Thrixspermum calceolus*, *Vanda concolor*, *V. fuscoviridis* and *Vandopsis gigantea*; all are large shrubby plants reaching more than a metre in height.

Other orchids with creeping rooting and binding rhizomes, sometimes with vine-like tendencies, cover mossy rocks and bases of large trees with an unbroken cover. The following are the species most common in this group:

<i>Bulbophyllum ambrosia</i> ,	<i>C. schultesii</i> ,	<i>Otochilus pseudoporrectus</i> ,
<i>B. andersonii</i> ,	<i>Epigeneium amplum</i> ,	<i>Pelatantheria insectifera</i> ,
<i>B. macraei</i> ,	<i>E. labuanum</i> ,	<i>Pholidota articulata</i> ,
<i>B. purpureifolium</i> ,	<i>Eria coronaria</i> ,	<i>Pholidota levelleana</i> ,
<i>B. reptans</i> ,	<i>E. pubescens</i> ,	<i>Ph. recurva</i> ,
<i>Callostylis rigida</i> ,	<i>Flickingeria fimbriata</i> ,	<i>Ph. roseans</i> ,
<i>Coelogyne fimbriata</i> ,	<i>Gastrochilus</i>	<i>Ph. rubra</i> ,
<i>C. lockii</i> ,	<i>pseudodistichus</i> ,	<i>Ph. yunnanensis</i> .
<i>C. malipoensis</i> ,	<i>Monomeria barbata</i> ,	

The majority of orchid species in humid, mossy, mixed and coniferous forests have no strong preferences as to epiphytic, lithophytic or terrestrial habit. Many species of this group are commonly observed on mossy limestone outcrops as lithophytes, terrestrials or epiphytes or on the bases of gnarled mossy trees on mountain summits. Most common among them are:

<i>Appendicula reflexa</i> ,	<i>D. loddigesii</i> ,	<i>E. corneri</i> ,
<i>Cleisostoma rostratum</i> ,	<i>D. nobile</i> ,	<i>E. coronaria</i> ,
<i>Cymbidium aloifolium</i> ,	<i>D. ochreatum</i> ,	<i>E. paniculata</i> ,
<i>C. bicolor</i> ,	<i>D. thyrsiflorum</i> ,	<i>E. pusilla</i> ,
<i>C. floribundum</i> ,	<i>Eria apertiflora</i> ,	<i>E. siamensis</i> ,
<i>C. suavissimum</i> ,	<i>E. carinata</i> ,	<i>E. sutepensis</i> ,
<i>Dendrobium chrysanthum</i> ,	<i>E. boniana</i> ,	<i>Liparis averyanoviana</i> ,
<i>D. fimbriatum</i> ,	<i>E. clausa</i> ,	<i>L. balansae</i> ,

Fig. 3: 1–8. Vegetation types: 1. Evergreen broad-leaved plane forests on alkaline soils. 2. Evergreen and semi-deciduous broad-leaved, mixed and coniferous limestone mountain forests. 3. Evergreen lowland forests on silicate rocks at 0–1000 m a.s.l. 4. Evergreen montane and highland forests on silicate rocks at 1000–3000 m a.s.l. 5. Semi-deciduous dry lowland forests. 6. Deciduous dry lowland forests and savanna-like woodlands. 7. Coastal vegetation, lowland wetlands and mangrove thickets. 8. Secondary, weed and agricultural plant communities, timber and industrial plantations.
1–6. Floristic regions: 1. Sikang–Yunnan Province. 2. South Chinese Province. 3. North Indochinese Province. 4. Central Annamese Province. 5. South Annamese Province. 6. South Indochinese Province.

<i>L. bootanensis</i> ,	<i>L. petelotii</i> ,	<i>Pelatantheria insectifera</i> ,
<i>L. distans</i> ,	<i>L. stricklandiana</i> ,	<i>Podochilus microphyllus</i> .
<i>L. latilabris</i> ,	<i>L. viridiflora</i> ,	
<i>L. manni</i> ,	<i>Oberonia cavaleriei</i> ,	

At the same time a number of a truly obligate epiphytic orchids, which never grow on rocks or the ground, are also found in semi-deciduous forest on limestone. These taxa usually grow on the mossy branches of old, dwarf, gnarled trees found along the tops of the ridges. Typical species of this group are:

<i>Bulbophyllum hirtum</i> ,	<i>D. lindleyi</i> ,	<i>Panisea yunnanensis</i> ,
<i>B. retusiusculum</i> ,	<i>D. longicornu</i> ,	<i>Phalaenopsis lobbii</i> ,
<i>B. umbellatum</i> ,	<i>D. nobile</i> ,	<i>Ph. manni</i> ,
<i>B. xylophyllum</i> ,	<i>D. truncatum</i> ,	<i>Pholidota missionariorum</i> ,
<i>Cerastostylis himalaica</i> ,	<i>Epigeneium chapaense</i> ,	<i>Porpax lanii</i> ,
<i>Chiloschista trudelii</i> ,	<i>Eria pannea</i> ,	<i>Renanthera citrina</i> ,
<i>Cleisostoma birmanicum</i> ,	<i>Gastrochilus minutiflorus</i> ,	<i>Schoenorchis gemmata</i> ,
<i>C. crochetii</i> ,	<i>Holcoglossum wangii</i> ,	<i>Thelasis pygmaea</i> ,
<i>C. fuerstenbergianum</i> ,	<i>Liparis delicatula</i> ,	<i>Thelasis khasiana</i> ,
<i>C. williamsonii</i> ,	<i>Luisia appressifolia</i> ,	<i>Trichotisia dasyphylla</i> ,
<i>Cryptochilus lutea</i> ,	<i>L. morsei</i> ,	<i>T. velutina</i> .
<i>Dendrobium acinaciforme</i> ,	<i>Malleola insectifera</i> ,	
<i>D. cariniferum</i> ,	<i>Ornithochilus difformis</i> ,	

Among obligate lithophytic orchids typical of these forests should be mentioned such species as: *Cheirostylis bipunctata*, *Ch. chinensis*, *Ch. cochinchinensis*, *Ch. marmorifolia*, *Ch. spatulata*, *Ch. yunnanensis*, *Ch. takeoi*, *Hemipilia calophylla*, *Liparis cordifolia*, *Oberonia ensiformis*, *Paphiopedilum concolor*, *P. dianthum*, *P. emersonii*, *P. hangianum*, *P. helenae*, *P. henryanum*, *P. × herrmanii*, *P. hirsutissimum*, *P. malipoense*, *P. micranthum*, *P. purpuratum*, *P. tranlienianum*, *P. vietnamense* and *Thunia alba*.

Broad-leaved, evergreen, closed and humid primary forest is found on the middle and lower reaches of the slopes below rocky limestone ridges. Numerous obligate terrestrial orchid species may be found there. Quite often they grow in locally damp pockets within karst limestone rocks filled by well-structured soil rich in humus. Typical species in such places are:

<i>Calanthe alleizetti</i> ,	<i>Cymbidium ensifolium</i> ,	<i>L. paradoxa</i> ,
<i>C. alismifolia</i> ,	<i>C. lancifolium</i> ,	<i>Nervilia punctata</i> ,
<i>C. argenteostriata</i> ,	<i>C. sinense</i> ,	<i>N. plicata</i> ,
<i>C. triplicata</i> ,	<i>Goodyera</i>	<i>Phaius flavus</i> ,
<i>Cephalantheropsis</i>	<i>schlechtendaliana</i> ,	<i>Ph. longicruris</i> ,
<i>longipes</i> ,	<i>G. viridiflora</i> ,	<i>Tropidia angulosa</i> ,
<i>Cryptostylis arachnites</i> ,	<i>Liparis nervosa</i> ,	<i>T. curculigoides</i> .

Within this forest type occur some rare tiny jewel orchids with beautifully marked leaves, including *Anoectochilus calcareus*, *A. roxburghii*, *Cheirostylis marmorifolia*, *Goodyera hispida* and *Rhomboda petelotii*. In these forests some rare saprophytic achlorophyllous orchids, such as *Cyrtosia javanica*, *Didimoplexiopsis khiriwongensis*, *Didymoplexis pallens* and *Epipogium roseum*, may also be seen. Occasionally *Vanilla albida*, a creeping epiphytic vine, may also be found there. This liana, with a juicy green succulent stem and leaves, may reach 10–12 m length. In open places terrestrial orchids with underground tubers such as *Bletilla ochracea*, *Habenaria ciliolaris*, *H. dentata*, *Phaius tankervilleae* occur. *Spiranthes sinensis* and *Arundina graminifolia* are common species in open secondary grasslands throughout the area (Averyanov *et al.* 2000).

6.3. Evergreen lowland forests on silicate rocks at elevations 0–1000 m a.s.l.

Evergreen broad-leaved tropical forests on acidic silicate base rocks in the past covered vast lowland, hilly and eroded low mountain areas all over Vietnam (Fig. 3). Granite, gneiss, rhyolite, dacite, sandstone, schist, shale and other rocks rich in silicate minerals are the most common basement rocks underlying soils in these regions. The altitude of the area, its annual rainfall amount and its seasonality are the next most important factors that determine the distribution and differentiation of these forests. Their more or less pronounced belt lies at about 800 m in northern Vietnam and below about 1000 m a.s.l. in the south of the country. The annual rainfall of these lowland regions ranges mostly from 1500–2000 up to 3000 mm. In dry areas of southern Vietnam that have less than 1500 mm annual rainfall, evergreen forests give way to semi-deciduous and deciduous dry lowland forests, open woodlands and savannas.

Most often broad-leaved lowland forests on silicate acidic soils are very wet and highly closed. These termophilous forests have a very rich species composition with numerous representatives more typical of tropical taxa within each forest strata. The largest trees sometimes reach 40–50 m high and more than 2 m in diameter, and are found in some types of lowland evergreen forests. All these trees belong mainly to mostly tropical families. The following families and genera occur most often in the first forest stratum (Nguyen Nghia Thin 1994, 1997a; Rundel 1999):

<i>Aceraceae</i> (<i>Acer</i>),	<i>Ixonanthaceae</i> (<i>Ixonanthes</i>),
<i>Anacardiaceae</i> (<i>Swintonia</i>),	<i>Lauraceae</i> (<i>Cinnamomum</i> , <i>Litsea</i> , <i>Machilus</i> ,
<i>Anisophylleaceae</i> (<i>Anisophyllea</i>),	<i>Notaphoebe</i> , <i>Phoebe</i>),
<i>Apocynaceae</i> (<i>Alstonia</i>),	<i>Meliaceae</i> (<i>Aglaia</i> , <i>Amoora</i> , <i>Chisocheton</i> ,
<i>Burseraceae</i> (<i>Canarium</i> , <i>Dacryodes</i>),	<i>Dysoxylon</i> , <i>Heynea</i> , <i>Sandoricum</i>),
<i>Clusiaceae</i> (<i>Calophyllum</i>),	<i>Moraceae</i> (<i>Artocarpus</i> , <i>Ficus</i>),
<i>Dipterocarpaceae</i> (<i>Dipterocarpus</i> , <i>Hopea</i>),	<i>Ulmaceae</i> (<i>Celtis</i>),
<i>Elaeocarpaceae</i> (<i>Elaeocarpus</i>),	<i>Sapindaceae</i> (<i>Sapindus</i> , <i>Xerospermum</i>),
<i>Euphorbiaceae</i> (<i>Macaranga</i> , <i>Endospermum</i> ,	<i>Sterculiaceae</i> (<i>Scaphium</i>),
<i>Bischofia</i> , <i>Sapium</i>),	<i>Theaceae</i> (<i>Schima</i>).
<i>Fagaceae</i> (<i>Castanopsis</i> , <i>Lithocarpus</i> ,	
<i>Quercus</i>),	

A great number of woody species comprise the lowest strata of undergrowth within these broad-leaved lowland woods. These are trees usually 5–15 m tall. Most common among them are species of the following families and genera (Rundel 1999):

<i>Aquifoliaceae</i> (<i>Ilex</i>),	<i>Meliaceae</i> (<i>Chisocheton</i>),
<i>Clusiaceae</i> (<i>Calophyllum</i> , <i>Cratoxylum</i> ,	<i>Myristicaceae</i> (<i>Horsfieldia</i>),
<i>Garcinia</i>),	<i>Myrtaceae</i> (<i>Cinnamomum</i>),
<i>Elaeocarpaceae</i> (<i>Elaeocarpus</i>),	<i>Rosaceae</i> (<i>Pygeum</i>),
<i>Euphorbiaceae</i> (<i>Baccaurea</i> , <i>Chaetocarpus</i>),	<i>Rubiaceae</i> (<i>Adina</i>),
<i>Fagaceae</i> (<i>Castanopsis</i> , <i>Lithocarpus</i>),	<i>Sabiaceae</i> (<i>Meliosma</i>),
<i>Icacinaceae</i> (<i>Apodytes</i>),	<i>Sapindaceae</i> (<i>Mischocarpus</i>),
<i>Juglandaceae</i> (<i>Engelhardtia</i>),	<i>Symplocaceae</i> (<i>Symplocos</i>),
<i>Lauraceae</i> (<i>Cryptocarya</i> , <i>Lindera</i> , <i>Litsea</i> ,	<i>Theaceae</i> (<i>Pyrenaria</i>),
<i>Machilus</i> , <i>Neolitsea</i>),	<i>Xanthophyllaceae</i> (<i>Xanthophyllum</i>).
<i>Magnoliaceae</i> (<i>Manglietia</i>),	

In northern Vietnam trees of the *Fabaceae*, *Fagaceae*, *Lauraceae*, *Magnoliaceae* and *Myrtaceae* commonly dominate the first forest stratum, though in southern Vietnam the largest proportion within the highest forests canopies are species of *Anacardiaceae*, *Burseraceae*,

Clusiaceae, Combretaceae, Dipterocarpaceae, Lauraceae, Meliaceae, Moraceae, Myrtaceae, Rubiaceae, Sapindaceae, Sterculiaceae and Theaceae.

Several strata within the canopy are always observed in these forests with a diverse assemblage of species in each tier. The lower shrub canopy of these forests is rich and diverse, with a notably large number of *Rubiaceae, Melastomataceae, Lauraceae* and *Acanthaceae*, which sometimes form a continuous cover 1.2–1.5 m in height. Numerous palms, lianas and diverse epiphytes form an important component of this forest community (Schmid 1974).

In more wet conditions on granite or dacite substrates some gymnosperm species comprise the first forest stratum at altitudes above 600–700 m a.s.l. Most common among them are *Podocarpus neriifolius, Dacrycarpus imbricatus* and *Dacrydium elatum*. Some lianas like *Freycinetia* (*Pandanaceae*), *Pseudostachyum polymorphum* (*Poaceae*), *Ancistrocladus cochinchinensis* (*Ancistrocladaceae*) and various rattans — *Calamus tetradactylus, C. pseudoscutellaris, C. bousingonii* — are very typical of these habitats (Rundel 1999). Rocky substrates on humid granite, gneiss or dacite slopes exhibit a development of interesting herb communities rich in terrestrial orchids. Typical terrestrial orchids in such shady humid habitats across the country are:

<i>Acanthephippium odoratum,</i>	<i>G. pulchellum,</i>	<i>P. indigoferus,</i>
<i>Anoectochilus roxburghii,</i>	<i>G. recurvum,</i>	<i>P. mishmensis,</i>
<i>A. siamensis,</i>	<i>G. siamense,</i>	<i>P. tankervilleae,</i>
<i>Calanthe lyroglossa,</i>	<i>Habenaria seshagiriana,</i>	<i>Tainia angustifolia,</i>
<i>Cephalantheropsis longipes,</i>	<i>Hetaeria oblongifolia,</i>	<i>T. hongkongensis,</i>
<i>C. obcordata,</i>	<i>H. pauciflora,</i>	<i>T. hookeriana,</i>
<i>Corymborkis veratrifolia,</i>	<i>Liparis nervosa,</i>	<i>T. latifolia,</i>
<i>Cymbidium ensifolium,</i>	<i>L. nigra,</i>	<i>T. pauciflora,</i>
<i>C. lancifolium,</i>	<i>Ludisia discolor,</i>	<i>T. ruybarrettoii,</i>
<i>C. sinense,</i>	<i>Malaxis octodentata,</i>	<i>T. viridifusca,</i>
<i>Geodorum attenuatum,</i>	<i>Paphiopedilum appletonianum,</i>	<i>Tropidia angulosa,</i>
<i>G. densiflorum,</i>	<i>P. callosum,</i>	<i>T. curculigoides.</i>
	<i>Phaius flavus,</i>	

A number of remarkable achlorophyllous mycotrophic orchids like *Aphyllorchis annamensis, A. evrardii, A. montana, Didimoplexiopsis khiriwongensis, Epipogium roseum, Lecanorchis javanica* and *Stereosandra javanica* also inhabit these forests. Among them is a large leafless liana *Galeola nudifolia* that may reach more than 10 m in length.

Other terrestrial orchids of this area prefer more open and dry habitats. These plants commonly develop underground tubers allowing them easily to survive during dry rainless period. Among these geophilous ephemeroïd orchids are:

<i>Brachycorythis laotica,</i>	<i>E. graminea,</i>	<i>Habenaria tonkinensis,</i>
<i>Cryptostylis arachnites,</i>	<i>E. macrobulbon,</i>	<i>Malaxis latifolia,</i>
<i>Cymbidium cyperifolium,</i>	<i>E. macrostachya,</i>	<i>Pachystoma pubescens,</i>
<i>Eulophia andamanensis,</i>	<i>E. spectabilis,</i>	<i>Spathoglottis pubescens.</i>
<i>E. flava,</i>	<i>E. tonkinensis,</i>	

Open wet rocks along mountain streams and rivers are common habitat of other orchids, like *Epipactis atromarginata, Arundina chinensis* and *Phaius longicornu*.

However epiphytes form the largest ecological group of orchids in evergreen lowland forests. More than half of all the species occurring here belong to this group. Usually they are small shrubs, short creeping vines or tufted plants growing in the canopies of large trees. Commonly occurring species of this group are:

<i>Acampe ochracea</i> ,	<i>C. atropurpureum</i> ,	<i>E. pannea</i> ,
<i>Acriopsis indica</i> ,	<i>C. bicolor</i> ,	<i>E. pubescens</i> ,
<i>A. liliifolia</i> ,	<i>C. dayanum</i> ,	<i>E. thao</i> ,
<i>Aerides falcata</i> ,	<i>Dendrobium acinaciforme</i> ,	<i>Flickingeria angustifolia</i> ,
<i>Ae. houlettiana</i> ,	<i>D. amabile</i> ,	<i>F. fimbriata</i> ,
<i>Ae. odorata</i> ,	<i>D. anosmum</i> ,	<i>F. forcipata</i> ,
<i>Agrostophyllum brevipes</i> ,	<i>D. aphyllum</i> ,	<i>Gastrochilus calceolaris</i> ,
<i>A. callosum</i> ,	<i>D. crystallinum</i> ,	<i>G. intermedius</i> ,
<i>A. planicaule</i> ,	<i>D. ellipsophyllum</i> ,	<i>Liparis cespitosa</i> ,
<i>Appendicula hexandra</i> ,	<i>D. farmeri</i> ,	<i>L. elliptica</i> ,
<i>Bulbophyllum affine</i> ,	<i>D. fimbriatum</i> ,	<i>Luisia psyche</i> ,
<i>B. astelidum</i> ,	<i>D. gratiosissimum</i> ,	<i>Micropera poilanei</i> ,
<i>B. averyanovii</i> ,	<i>D. heterocarpum</i> ,	<i>Ornithochilus difformis</i> ,
<i>B. blepharistes</i> ,	<i>D. lindleyi</i> ,	<i>Pholidota articulata</i> ,
<i>B. careyanum</i> ,	<i>D. nobile</i> ,	<i>Ph. chinensis</i> ,
<i>B. devangiriense</i> ,	<i>D. ochraceum</i> ,	<i>Ph. convallariae</i> ,
<i>B. elassonotum</i> ,	<i>D. oligophyllum</i> ,	<i>Ph. guibertiae</i> ,
<i>B. frostii</i> ,	<i>D. parishii</i> ,	<i>Ph. imbricata</i> ,
<i>B. hiepii</i> ,	<i>D. porphyrophyllum</i> ,	<i>Ph. levelleana</i> ,
<i>B. hirtum</i> ,	<i>D. salaccense</i> ,	<i>Ph. pallida</i> ,
<i>B. odoratissimum</i> ,	<i>D. stuartii</i> ,	<i>Ph. recurva</i> ,
<i>B. pecten-veneris</i> ,	<i>D. terminale</i> ,	<i>Ph. rubra</i> ,
<i>B. retusiusculum</i> ,	<i>D. thyrsiflorum</i> ,	<i>Polystachya concreta</i> ,
<i>B. sigaldiae</i> ,	<i>D. truncatum</i> ,	<i>Pomatocalpa spicata</i> ,
<i>B. umbellatum</i> ,	<i>D. unicum</i> ,	<i>Pteroceras leopardinum</i> ,
<i>Ceratostylis himalaica</i> ,	<i>D. uniflorum</i> ,	<i>Robiquetia spathulata</i> ,
<i>C. radiata</i> ,	<i>Eparmatostigma dives</i> ,	<i>R. succisa</i> ,
<i>C. siamensis</i> ,	<i>Eria acervata</i> ,	<i>Sarcoglyphis mirabilis</i> ,
<i>C. subulata</i> ,	<i>E. albidotomentosa</i> ,	<i>Thecopus maingayi</i> ,
<i>Cleisostoma birmanicum</i> ,	<i>E. amica</i> ,	<i>Thecostele alata</i> ,
<i>C. duplicilobum</i> ,	<i>E. apertiflora</i> ,	<i>Thrixspermum pauciflorum</i> ,
<i>C. fuerstenbergianum</i> ,	<i>E. clausa</i> ,	<i>Trias disciflora</i> ,
<i>C. williamsonii</i> ,	<i>E. corneri</i> ,	<i>T. nasuta</i> ,
<i>C. lentiginosa</i> ,	<i>E. eriopsidobulbon</i> ,	<i>Trichotosia dalatensis</i> ,
<i>C. viscosa</i> ,	<i>E. obscura</i> ,	<i>T. microphylla</i> ,
<i>Cymbidium aloifolium</i> ,	<i>E. paniculata</i> ,	<i>T. pulvinata</i> .

Among epiphytic species in these forests are numerous highly specialized branch epiphytes that inhabit the terminal zone of tree canopies. These small thin plants become established on small branchlets and on coriaceous long-lived leaves. Among them are:

<i>Biermannia calcarata</i> ,	<i>E. perpusilla</i> ,	<i>Pteroceras semiteretifolium</i> ,
<i>Bulbophyllum bryoides</i> ,	<i>E. pusilla</i> ,	<i>Taeniophyllum</i>
<i>B. catenarium</i> ,	<i>Malleola insectifera</i> ,	<i>fasciculatum</i> ,
<i>B. crassiusculifolium</i> ,	<i>Pennilabium angraecum</i> ,	<i>Thelasis pygmaea</i> ,
<i>B. sessile</i> ,	<i>Porpax elwesii</i> ,	<i>Thrixspermum formosanum</i> ,
<i>Eria muscicola</i> ,	<i>P. reticulata</i> ,	<i>Trichotosia dasyphylla</i> .

Larger epiphytic orchid lianas are also important component of lowland woods on silicate rocks. Among them most characteristic species are:

<i>Arachnis annamensis</i> ,	<i>Renanthera annamensis</i> ,	<i>Thrixspermum calceolus</i> ,
<i>Callostylis rigida</i> ,	<i>R. imschootiana</i> ,	<i>Th. centipeda</i> .
<i>Epigeneium amplum</i> ,	<i>Staurochilus fasciatus</i> ,	

Few lithophytic orchids are found in lowland evergreen forests. Normally the relatively rare orchids develop on acidic silicate rock outcrops that occur along canyons of montane streams and rivers. The following species often prefer these habitats within the lowland broad-leaved forests:

<i>Dendrobium fimbriatum</i> ,	<i>Liparis elliptica</i> ,	<i>Pholidota chinensis</i> ,
<i>Doritis pulcherrima</i> ,	<i>Ludisia discolor</i> ,	<i>Ph. imbricata</i> ,
<i>Eria spirodela</i> ,	<i>Paphiopedilum</i>	<i>Ph. pallida</i> ,
<i>Flickingeria fimbriata</i> ,	<i>appletonianum</i> ,	<i>Podochilus microphyllus</i> .
<i>Habenaria rhodocheila</i> ,	<i>P. delenatii</i> ,	

6.4. Evergreen montane and highland forests on silicate rocks at elevations between 1000–3000 m a.s.l.

Evergreen montane and upland forests are developed across large mountain areas of Vietnam at altitude above 900–1000 m in the north and above 1200–1400 m a.s.l. in the south (Fig. 3). The great majority of these mountain systems are composed of acidic silicate rocks. The humid and cool climatic conditions of these mountain areas produce a relatively sharp distinction in vegetation structure between lowland and montane forest communities. This delineation is marked by a decline in the number of taxa of tropical families such as the *Anacardiaceae*, *Dipterocarpaceae*, *Euphorbiaceae*, *Meliaceae* and *Simaroubaceae* and an increase in dominance of subtropical and temperate families like *Fagaceae*, *Theaceae*, *Magnoliaceae* and a diverse assemblage of conifers. Most *Dipterocarpaceae* trees, for example, drop out at elevations of 600–900 m, while the upper limit of this family commonly occurs at elevations below 1100 m a.s.l. Similarly, the lower altitudinal limits of many characteristic montane tree species are at 900–1200 m a.s.l. (Rundel 1999).

Montane forests are generally lower in stature than lowland forest communities, and are characterized by a dense evergreen upper canopy. Lianas are much less abundant and diverse than in lowland evergreen forests, while epiphytes are particularly notable in their abundance and diversity (Rundel 1999). Montane forest habitats in Vietnam have annual rainfall of 2000 to more than 3000 mm and relatively short or no dry seasons.

Primary montane habitats in Vietnam include a range of intergrading communities dominated by evergreen broad-leaved trees, conifers and mixed conifer/broad-leaved forest. Broad-leaved forests are commonly situated on slopes of mountain ridges and include a great number of tree species that may be observed as subdominants in the first forest stratum. Most common among them are representatives of the following families and genera:

<i>Aceraceae</i> (<i>Acer</i>),	<i>Lauraceae</i> (<i>Actinodaphne</i> , <i>Cinnamomum</i> ,
<i>Clusiaceae</i> (<i>Garcinia</i>),	<i>Cryptocarya</i> , <i>Lindera</i> , <i>Litsea</i> , <i>Machilus</i> ,
<i>Elaeocarpaceae</i> (<i>Elaeocarpus</i>),	<i>Neolitsea</i> , <i>Nothaphoebe</i> , <i>Phoebe</i>),
<i>Fabaceae</i> (<i>Cylindrokelupha</i>),	<i>Magnoliaceae</i> (<i>Michelia</i> , <i>Talauma</i>),
<i>Fagaceae</i> (<i>Castanopsis</i> , <i>Lithocarpus</i> ,	<i>Myrtaceae</i> (<i>Syzygium</i>),
<i>Quercus</i>),	<i>Rosaceae</i> (<i>Pyrus</i> , <i>Sorbus</i> , <i>Pygeum</i>),
<i>Hamamelidaceae</i> (<i>Rhodoleia</i> , <i>Syningtonia</i>),	<i>Sapotaceae</i> (<i>Madhuca</i>),
<i>Illiciaceae</i> (<i>Illicium</i>),	<i>Theaceae</i> (<i>Eurya</i> , <i>Pyrenaria</i> , <i>Schima</i> ,
<i>Juglandaceae</i> (<i>Engelhardtia</i>),	<i>Gordonia</i>),
	<i>Ulmaceae</i> (<i>Gironniera</i>).

Representatives of *Acanthaceae*, *Melastomataceae*, *Rubiaceae* and *Urticaceae* dominate in the undergrowth stratum of woody and semi-woody species. Here some woody ferns (*Ctenitopsis*, *Cibotium*, *Cyathea*) that may reach 10 metres and more high in humid river canyons are also common. White, pink or bright red mushroom-like root parasites of the *Balanophoraceae* (*Balanophora*, *Rhopalocnemis*) and *Rafflesiaceae* (*Sapria*) families are not rare in these habitats.

Along rocky mountain streams in deep wet canyons are rich communities dominated by taxa of the *Aceraceae* (*Acer*), *Betulaceae* (*Carpinus*), *Rosaceae* (*Pyrus*, *Pygeum*), *Elaeocarpaceae* (*Sloanea*), *Myrsinaceae* (*Ardisia*), *Oleaceae* (*Fraxinus*) and *Araliaceae* (*Macropanax*, *Schefflera*, *Trevesia*, *Tupidanthus*). A number of tree and shrub species comprise a typical riparian community on better-drained rocky soils. Taxa within these humid riparian habitats include species of *Lauraceae* (*Cinnamomum*, *Eugenia*), *Fagaceae* (*Castanopsis*), *Salicaceae* (*Salix*), *Sterculiaceae* (*Reevesia*), *Nyssaceae* (*Nyssa*), *Elaeocarpaceae* (*Elaeocarpus*), *Pandanaceae* (*Freycinetia*, *Pandanus*), *Moraceae* (*Ficus*), *Rubiaceae* (*Lasianthus*), *Chloranthaceae* (*Chloranthus*), palms (*Caryota sympetala*, *Pinanga banaensis*), ferns (*Angiopteris*, *Cibotium*, *Cyathea*, *Cyclosorus*, *Marattia*, *Polystichum*, *Rumohra*) and large forest herbs, like *Begonia* (*Begoniaceae*), *Curculigo* (*Hypoxidaceae*), *Impatiens* (*Balsaminaceae*) and *Musa* (*Musaceae*). Soils kept constantly wet by mists along steep stream slopes often support diverse assemblages of terrestrial orchids and other herbs. The most typical terrestrial orchids here are:

<i>Acanthephippium simplex</i> ,	<i>C. lyroglossa</i> ,	<i>G. fumata</i> ,
<i>A. striatum</i> ,	<i>C. sylvatica</i> ,	<i>Habenaria pantlingiana</i> ,
<i>Anoectochilus acalcaratus</i> ,	<i>C. velutina</i> ,	<i>Mischobulbon cordifolium</i> ,
<i>A. chapaënsis</i> ,	<i>Cephalantheropsis</i>	<i>M. macranthum</i> ,
<i>A. elwesii</i> ,	<i>longipes</i> ,	<i>Nephelaphyllum</i>
<i>A. lanceolatus</i> ,	<i>C. obcordata</i> ,	<i>tenuiflorum</i> ,
<i>A. lylei</i> ,	<i>Collabium assamicum</i> ,	<i>Paphiopedilum</i>
<i>A. roxburghii</i> ,	<i>C. chinense</i> ,	<i>appletonianum</i> ,
<i>A. siamensis</i> ,	<i>C. chloranthum</i> ,	<i>P. callosum</i> ,
<i>A. sikkimensis</i> ,	<i>Collabiopsis formosanum</i> ,	<i>Phaius flavus</i> ,
<i>A. tridentatus</i> ,	<i>Cymbidium ensifolium</i> ,	<i>Ph. tankervilleae</i> ,
<i>Apostasia nuda</i> ,	<i>C. lancifolium</i> ,	<i>Pristiglottis umbrosa</i> ,
<i>A. odorata</i> ,	<i>C. sinense</i> ,	<i>Tainia hookeriana</i> ,
<i>A. wallichii</i> ,	<i>C. wilsonii</i> ,	<i>Zeuxine nervosa</i> ,
<i>Calanthe clavata</i> ,	<i>Diglyphosa evrardii</i> ,	<i>Z. parvifolia</i> .
<i>C. densiflora</i> ,	<i>Eria gagnepainii</i> ,	
<i>C. herbacea</i> ,	<i>Goodyera foliosa</i> ,	

Some rare, leafless, achlorophyllous mycotrophic orchids occur in similar conditions, including *Aphyllorchis annamensis*, *A. evrardii*, *A. montana*, *Chamaegastrodia poilanei*, *Lecanorchis javanica*, *Pristiglottis saprophytica* and *Yoania prainii*. Large yellowish vines of *Galeola nudifolia*, which can reach 6–8 m long also occur in these habitats. In more open sunny places some terrestrial tuberiferous and liana orchids such as *Cryptostylis arachnites*, *Eulophia spectabilis*, *Peristylus calcaratus*, *P. candidus*, *P. chapaënsis*, *P. constrictus*, *P. densus*, *P. prainii*, *P. tentaculatus*, *Vanilla albida*, *V. annamica*, *V. aphylla* and *V. pierrei* may be found. A number of lithophytic orchids inhabit sheer rocky cliffs along mountain streams and rivers in these forests. The following is a list of such species in these habitats:

<i>Appendicula cornuta</i> ,	<i>D. sociale</i> ,	<i>P. delenatii</i> ,
<i>A. hexandra</i> ,	<i>Flickingeria fimbriata</i> ,	<i>P. gratrixianum</i> ,
<i>A. reflexa</i> ,	<i>Liparis luteola</i> ,	<i>Pholidota levelleana</i> ,
<i>Bulbophyllum tixieri</i> ,	<i>Monomeria barbata</i> ,	<i>P. rubra</i> ,
<i>Dendrobium alleizettii</i> ,	<i>Paphiopedilum</i>	<i>Podochilus microphyllus</i> .
<i>D. fimbriatum</i> ,	<i>appletonianum</i> ,	

However epiphytic orchids represent the largest and most diverse group of the family in primary mountain forests. Common species among them occurring in different areas of the country at elevations between 1000–2500 m a.s.l. are:

<i>Agrostophyllum callosum</i> ,	<i>D. farmeri</i> ,	<i>L. stricklandiana</i> ,
<i>Appendicula gracilis</i> ,	<i>D. faulhaberianum</i> ,	<i>Malleola seidenfadenii</i> ,
<i>Bulbophyllum</i>	<i>D. gratiosissimum</i> ,	<i>Oberonia acaulis</i> ,
<i>crassiusculifolium</i> ,	<i>D. hercoglossum</i> ,	<i>O. anthropophora</i> ,
<i>B. delitescens</i> ,	<i>D. heterocarpum</i> ,	<i>O. caulescens</i> ,
<i>B. elassonotum</i> ,	<i>D. khanhoaense</i> ,	<i>O. dalatensis</i> ,
<i>B. frostii</i> ,	<i>D. langbianense</i> ,	<i>O. dolichocaulis</i> ,
<i>B. hymenanthum</i> ,	<i>D. linguella</i> ,	<i>O. ensiformis</i> ,
<i>B. longiflorum</i> ,	<i>D. lomatochilum</i> ,	<i>O. evrardii</i> ,
<i>B. luanii</i> ,	<i>D. longicornu</i> ,	<i>O. langbianensis</i> ,
<i>B. monanthum</i> ,	<i>D. nobile</i> ,	<i>O. quadridentata</i> ,
<i>B. odoratissimum</i> ,	<i>D. oligophyllum</i> ,	<i>Panisea tricallosa</i> ,
<i>B. orientale</i> ,	<i>D. pachyglossum</i> ,	<i>Paphiopedilum villosum</i> ,
<i>B. pecten-veneris</i> ,	<i>D. parishii</i> ,	<i>Pennilabium angraecum</i> ,
<i>B. picturatum</i> ,	<i>D. uniflorum</i> ,	<i>Pholidota articulata</i> ,
<i>B. putidum</i> ,	<i>Epigeneium amplum</i> ,	<i>Ph. chinensis</i> ,
<i>B. retusiusculum</i> ,	<i>E. cacuminis</i> ,	<i>Ph. convallariae</i> ,
<i>B. sigaldiae</i> ,	<i>Eria acervata</i> ,	<i>Ph. levelleana</i> ,
<i>Callostylis rigida</i> ,	<i>E. bidupensis</i> ,	<i>Ph. pachyglossa</i> ,
<i>Ceratostylis himalaica</i> ,	<i>E. biflora</i> ,	<i>Ph. recurva</i> ,
<i>C. radiata</i> ,	<i>E. carunculosa</i> ,	<i>Podochilus microphyllus</i> ,
<i>C. siamensis</i> ,	<i>E. clausa</i> ,	<i>Polystachya concreta</i> ,
<i>C. subulata</i> ,	<i>E. floribunda</i> ,	<i>Pomatocalpa spicata</i> ,
<i>Cleisostoma birmanicum</i> ,	<i>E. foetida</i> ,	<i>Pteroceras leopardinum</i> ,
<i>C. discolor</i> ,	<i>E. globulifera</i> ,	<i>Robiquetia spatulata</i> ,
<i>C. duplicilobum</i> ,	<i>E. lactiflora</i> ,	<i>R. succisa</i> ,
<i>C. striatum</i> ,	<i>E. lanigera</i> ,	<i>Schoenorchis eberhardtii</i> ,
<i>C. williamsonii</i> ,	<i>E. lasiopetala</i> ,	<i>Sunipia andersonii</i> ,
<i>Coelogyne assamica</i> ,	<i>E. paniculata</i> ,	<i>S. pallida</i> ,
<i>C. brachyptera</i> ,	<i>E. pannea</i> ,	<i>S. scariosa</i> ,
<i>C. cycnoches</i> ,	<i>E. tomentosa</i> ,	<i>Taeniophyllum</i>
<i>C. eberhardtii</i> ,	<i>E. truncata</i> ,	<i>glandulosum</i> ,
<i>C. fimbriata</i> ,	<i>Flickingeria angustifolia</i> ,	<i>T. minimum</i> ,
<i>C. lawrenceana</i> ,	<i>F. ritaiana</i> ,	<i>T. obtusum</i> ,
<i>C. sanderae</i> ,	<i>Gastrochilus calceolaris</i> ,	<i>T. pahangense</i> ,
<i>C. stricta</i> ,	<i>G. hainanensis</i> ,	<i>Trichotosia dalatensis</i> ,
<i>C. viscosa</i> ,	<i>G. intermedius</i> ,	<i>T. dasyphylla</i> ,
<i>Cymbidium schroederi</i> ,	<i>G. pseudodistichus</i> ,	<i>T. microphylla</i> ,
<i>Dendrobium aduncum</i> ,	<i>G. simplicilabius</i> ,	<i>T. pulvinata</i> ,
<i>D. amabile</i> ,	<i>Holcoglossum amesianum</i> ,	<i>T. velutina</i> ,
<i>D. aphyllum</i> ,	<i>H. lingulatum</i> ,	<i>Vanda bidupensis</i> ,
<i>D. bellatulum</i> ,	<i>H. subulifolium</i> ,	<i>V. concolor</i> ,
<i>D. cariniferum</i> ,	<i>Hygrochilus parishii</i> ,	<i>V. denisoniana</i> ,
<i>D. crystallinum</i> ,	<i>Liparis elliptica</i> ,	<i>V. pumila</i> .
<i>D. dalatense</i> ,	<i>L. latilabris</i> ,	
<i>D. ellipsophyllum</i> ,	<i>L. luteola</i> ,	

A number of gymnosperm trees commonly become more or less important elements of the forest communities on mountain slopes near the ridge summits. Among them are such species as *Cephalotaxus mannii*, *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Nageia wallichiana*, *Podocarpus neriifolius* and *Taxus wallichiana*. Some coniferous species like *Fokienia hodginsii*, *Keteleeria evelyniana*, *Pinus krempfii* and *P. dalatensis* may reach 40–45 m in height and 2 m in

diameter. These large conifers are generally emergents above a matrix of forest dominated by *Fagaceae*, *Lauraceae* and *Magnoliaceae*.

On the summits of mountain systems and along the tops of ridges, broad-leaved, evergreen, closed, wet forests give way to mixed and coniferous forests dominated by gymnosperm species. Less humid montane habitats up to 2000 m often support open forests of *Keteleeria evelyniana*, *Pinus kesiya* and *P. merkusii* — three montane conifers widespread throughout Vietnam (Nguyen Tien Hiep *et al.* 1999).

Humid montane areas at about 1200–2400 m throughout Vietnam may support a rich forest dominated by *Fokienia hodginsii*, *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Cunninghamia konishii*, *Nageia wallichiana* and *Podocarpus neriifolius* (Nguyen Tien Hiep *et al.* 1999; Rundel 1999).

A coniferous community of distinctly temperate affinities occurs in northern Vietnam at higher elevations between 2400–2900 m in only the northwestern part of the country, with occasional dominance of *Tsuga dumosa* and *Abies delavayi* (Nguyen Tien Hiep *et al.* 1999; Rundel 1999).

Pinus kwangtungensis and *P. wangii* are typical coniferous species in a few scattered montane regions in northern and central Vietnam. Humid highland montane coniferous forests of southern and central Vietnam are typically composed of two local endemic species of pine — *Pinus krempfii* and *P. dalatensis* (Nguyen Tien Hiep *et al.* 1999; Rundel 1999).

The subcanopy tree and shrub stratum of open pine forests commonly includes representatives of the following families and genera (Schmid 1974):

<i>Ericaceae</i> (<i>Agapetes</i> , <i>Craibiodendron</i>),	<i>Proteaceae</i> (<i>Helicia</i>),
<i>Euphorbiaceae</i> (<i>Breynia</i> , <i>Phyllanthus</i>),	<i>Rhamnaceae</i> (<i>Rhamnus</i>),
<i>Fabaceae</i> (<i>Albizia</i> , <i>Archidendron</i>),	<i>Rubiaceae</i> (<i>Gardenia</i>),
<i>Fagaceae</i> (<i>Lithocarpus</i> , <i>Quercus</i>),	<i>Theaceae</i> (<i>Adinandra</i> , <i>Anneslea</i> , <i>Eurya</i> ,
<i>Myricaceae</i> (<i>Myrica</i>),	<i>Ternstroemia</i>).
<i>Myrtaceae</i> (<i>Tristania</i>),	

Epiphytic orchids and ferns are abundant and diverse in montane pine forests. However these plants reach their maximum abundance in coniferous montane cloud forests on mountain peaks and along the highest ridges, which are commonly bathed in moist clouds, heavy dew and fog throughout the year. Annual rainfall in these areas may reach 4000 mm and more without any pronounced dry season. Cold winters with night temperatures falling below freezing determine the obvious seasonal character of the highland vegetation and encourages the appearance of a number of semi-deciduous and deciduous trees and shrub species in such habitats. Soils here are shallow, but rich in organic matter and highly acid.

Very old and often gnarled coniferous and ericaceous trees and dwarf shrubs are the main dominants in such highland communities. Among the most common are *Fokienia hodginsii*, *Pinus dalatensis*, *P. kesiya*, *P. krempfii*, *P. wangii*, *Podocarpus neriifolius* and *Nageia wallichiana*, as well as numerous species of *Agapetes*, *Lyonia*, *Rhododendron* and *Vaccinium*. Trees here rarely reach more than 10 m in height. Often distinctive communities of low woody ericaceous thicket 3–5 m in height cover isolated mountain peaks and narrow ridges. Many interesting highly localized plant species occur only in these highland conditions. In the extreme northwestern highland regions of the country occasional emergents in cloud forests may appear, such as *Tsuga dumosa* and *Abies delavayi*. Lush growths of epiphytic mosses, lichens, orchids and ferns cover all tree stems, branches, ground and rock outcrops in such habitats with a thick moist and unbroken cover. The most common orchid species here are:

<i>Bulbophyllum pinicolum</i> ,	<i>B. thaiorum</i> ,	<i>C. filipeda</i> ,
<i>B. pumilio</i> ,	<i>Ceratostylis himalaica</i> ,	<i>C. mooreana</i> ,
<i>B. semiteretifolium</i> ,	<i>Coelogyne calcicola</i> ,	<i>C. ridleyi</i> ,

<i>C. rigida</i> ,	<i>E. bipunctata</i> ,	<i>O. fuscus</i> ,
<i>C. schultesii</i> ,	<i>E. globifera</i> ,	<i>Panisea albiflora</i> ,
<i>Cymbidium devonianum</i> ,	<i>E. paniculata</i> ,	<i>Pholidota articulata</i> ,
<i>C. eburneum</i> ,	<i>E. pannea</i> ,	<i>Ph. convallariae</i> ,
<i>C. lowianum</i> ,	<i>E. siamensis</i> ,	<i>Ph. levelleana</i> ,
<i>Dendrobium christyanum</i> ,	<i>E. thao</i> ,	<i>Ph. recurva</i> ,
<i>D. virgineum</i> ,	<i>Liparis bootanensis</i> ,	<i>Schoenorchis gemmata</i> ,
<i>D. wattii</i> ,	<i>L. cespitosa</i> ,	<i>Sunipia annamensis</i> ,
<i>Epigeneium cacuminis</i> ,	<i>L. chapaënsis</i> ,	<i>Trichotosia dasyphylla</i> ,
<i>E. chapaënsis</i> ,	<i>L. compressa</i> ,	<i>T. microphylla</i> .
<i>Eria amica</i> ,	<i>Monomeria dichroma</i> ,	
<i>E. apertiflora</i> ,	<i>Otochilus albus</i> ,	

On the highest peaks of southern Vietnam a few orchid species such as *Cymbidium insigne*, *Goodyera schlechtendaliana*, *Bulbophyllum ngoclinensis* and *B. reptans*, are observed.

The connection of the highlands of Vietnam with the higher elevation areas of southern China is shown by the numerous temperate floristic elements common to both areas (Nguyen Nghia Thin 1998; Nguyen Nghia Thin & Nguyen Thi Thoi 1998). A number of terrestrial and lithophytic orchids occurring in the Vietnamese highlands, mainly at altitudes above 2000 m a.s.l., belong to this group. Among these are such species as:

<i>Amitostigma bidupense</i> ,	<i>G. schlechtendaliana</i> ,	<i>P. maculata</i> ,
<i>Amitostigma keiskeoides</i> ,	<i>Hancockia uniflora</i> ,	<i>P. praecox</i> ,
<i>Gastrodia taiensis</i> ,	<i>Platanthera angustata</i> ,	<i>P. vietnamensis</i> .
<i>Goodyera foliosa</i> ,	<i>Pleione grandiflora</i> ,	

6.5. Semi-deciduous and deciduous dry lowland forests at elevations between 0–500 (700) m a.s.l.

In Vietnam the semi-deciduous and deciduous dry lowland forests, as well as open, savanna-like woodlands represent the eastern extension of this vegetation type that extends across all of mainland South-East Asia. These vegetation types are present in areas receiving less than 2000 mm annual rainfall and experiencing 5-7 months of drought. These plant communities are distributed in the semi-arid climatic zones of southern Vietnam at elevations between 0–500 (700) m a.s.l. and mainly form over basalts and on shallow granitic soils (Fig. 3). Most of these open woodlands have been highly affected by human activities and represent one of the most endangered types of native vegetation left in Vietnam. In intact habitats emergent trees such as *Tetrameles nudiflora* or *Lagerstroemia angustifolia* growing along the edges of these forests may reach 40–50 m in height. However the primary dominants in most dry lowland forests are not taller than 15–20 m.

Semi-deciduous trees of the *Dipterocarpaceae* are very typical within the highest canopy tier of the dry lowland forests of Vietnam. Other main dominants of the first forest stratum belong to many families. Most typical among them are (Schmid 1974):

<i>Anacardiaceae</i> (<i>Buchanania</i> ,	<i>Dilleniaceae</i> (<i>Dillenia</i>),
<i>Dracontomelum</i>),	<i>Dipterocarpaceae</i> (<i>Dipterocarpus</i> , <i>Hopea</i> ,
<i>Annonaceae</i> (<i>Miliusa</i>),	<i>Shorea</i>),
<i>Bignoniaceae</i> (<i>Stereospermum</i>),	<i>Ebenaceae</i> (<i>Diospyros</i>),
<i>Bombacaceae</i> (<i>Bombax</i>),	<i>Fabaceae</i> (<i>Afzelia</i> , <i>Albizzia</i> , <i>Cassia</i> ,
<i>Burseraceae</i> (<i>Canarium</i>),	<i>Dalbergia</i> , <i>Pterocarpus</i>),
<i>Combretaceae</i> (<i>Anogeissus</i> , <i>Terminalia</i>),	<i>Fagaceae</i> (<i>Lithocarpus</i> , <i>Quercus</i>),
<i>Datisceaeae</i> (<i>Tetrameles</i>),	<i>Lythraceae</i> (<i>Lagerstroemia</i>),

Meliaceae (*Aglaia*, *Amoora*, *Sandoricum*,
Toona),
Moraceae (*Artocarpus*, *Ficus*),
Myrtaceae (*Eugenia*),
Rubiaceae (*Adina*),
Simaroubaceae (*Irvingia*),

Sapindaceae (*Erioglossum*, *Pometia*,
Sapindus),
Sapotaceae (*Palaquium obovatum*),
Sterculiaceae (*Sterculia*, *Pterospermum*),
Ulmaceae (*Celtis*, *Holoptelea*),
Verbenaceae (*Vitex*).

A great number of smaller trees and shrubs are observed in the undergrowth of these open forests as well as a high diversity and abundance of grasses, bamboos and cycads. The grass cover frequently reaches as much as 1–1.5 m in height. Notably important among the grasses are *Arundinella*, *Pseudopogonatherum*, *Imperata*, *Heteropogon*, *Themeda* and *Alloteropsis*. Lianas and epiphytes are common, but nowhere abundant. At the same time small creeping succulent vines like *Dischidia* and *Hoya*, as well as large epiphytic ferns such as *Aglaomorpha*, *Drynaria* and *Platyserium* are very typical of these forests.

Despite the dry conditions the diversity of epiphytic orchids in dry lowland Dipterocarp forests in southern Vietnam is very high with notable local endemism. Most of these orchid species have obvious xeromorphic features. Numerous Vietnamese orchids belong to this group. Among them are:

Acampe papillosa,
Acriopsis indica,
A. liliifolia,
Adenoncos vesiculosa,
Aerides crassifolia,
A. falcata,
A. houlletiana,
A. multiflora,
Arachnis annamensis,
A. cannaeformis,
A. hookeriana,
A. labrosa,
A. maingayi,
Ascocentrum
christensonianum,
A. curvifolium,
A. garayi,
Ascolabium pusillum,
Brachypeza laotica,
Bulbophyllum averyanovii,
B. bariense,
B. blepharistes,
B. dayanum,
B. elassonotum,
B. hirtum,
B. lemniscatoides,
B. orientale,
B. refractum,
B. tripudians,
Chiloschista exuperei,
Ch. parishii,

Christensonia vietnamica,
Cleisomeria lanatum,
Cleisostoma equestre,
C. inflatum,
Coelogyne lentiginosa,
Cymbidium aloifolium,
C. atropurpureum,
C. bicolor,
Dendrobium crumenatum,
D. crystallinum,
D. exile,
D. farmeri,
D. gratiosissimum,
D. indivisum,
D. lindleyi,
D. lomatochilum,
D. podagraria,
D. porphyrophyllum,
D. pseudotenellum,
D. secundum,
D. truncatum,
D. unicum,
Eparmatostigma dives,
Eria acervata,
E. cochinchinensis,
E. obscura,
E. pannea,
Luisia brachystachys,
L. filiformis,
L. psyche,
Malaxis ophridis,

Nervilia plicata,
Oberonia acaulis,
O. caulescens,
O. emarginata,
O. gammiei,
O. longibracteata,
O. lycopodioides,
O. rasmussenii,
O. rufilabris,
O. tixieri,
O. trochopetala,
Papilionanthe hookeriana,
P. pedunculata,
Pelatantheria
ctenoglossum,
P. eakroensis,
Peristylus densus,
Pholidota levelleana,
Ph. rubra,
Polystachya concreta,
Rhynchostylis coelestis,
R. gigantea,
R. retusa,
Staurochilus fasciatus,
Thecopus maingayi,
Thecostele alata,
Thrixspermum centipeda,
Trichoglottis retusa,
T. seidenfadenii,
Trichotisia dasyphylla,
Vanda pumila.

The diversity of herbaceous perennials in dry open lowland forests and woodlands is remarkably large. Most such species belong to specific group of ephemeroïd plants that develop underground tubers or thick rhizomes. Their leaves sometimes completely die back during the dry season and appear again with the return of the rains. Such species usually bloom during first weeks of the rainy season, but some of them bring flower during the dry season just before the first rains. Many terrestrial tuberiferous orchids inhabit these woods. Common species of this group are:

<i>Anthogonium gracile</i> ,	<i>G. recurvum</i> ,	<i>H. rostrata</i> ,
<i>Brachycorythis galeandra</i> ,	<i>G. siamense</i> ,	<i>H. rumphii</i> ,
<i>B. laotica</i> ,	<i>Habenaria apetala</i> ,	<i>H. viridiflora</i> ,
<i>Eulophia andamanensis</i> ,	<i>H. commelinifolia</i> ,	<i>Pachystoma pubescens</i> ,
<i>E. flava</i> ,	<i>H. dentata</i> ,	<i>Pecteilis cochinchinensis</i> ,
<i>E. graminea</i> ,	<i>H. erostrata</i> ,	<i>P. henryi</i> ,
<i>E. macrobulbon</i> ,	<i>H. lindleyana</i> ,	<i>P. susannae</i> ,
<i>E. pauciflora</i> ,	<i>H. lucida</i> ,	<i>Spathoglottis affinis</i> ,
<i>E. pulchra</i> ,	<i>H. mandersii</i> ,	<i>S. aurea</i> ,
<i>E. spectabilis</i> ,	<i>H. medioflexa</i> ,	<i>S. eburnea</i> ,
<i>Geodorum attenuatum</i> ,	<i>H. myriotricha</i> ,	<i>S. plicata</i> ,
<i>G. densiflorum</i> ,	<i>H. poilanei</i> ,	<i>S. pubescens</i> .
<i>G. pulchellum</i> ,	<i>H. rostellifera</i> ,	

6.6. Coastal vegetation, lowland wetlands and mangrove thickets

A number of specific types of vegetation may be seen along the coast of Vietnam (Fig. 3). Primary are such plant community as coastal scrub, coastal lowland wetlands and mangrove thickets. In most cases all these types of vegetation have been heavily influenced by human activities and greatly modified from their natural condition. Many of these areas with mean annual rainfall less than 1700 mm are the most arid and fragile within Vietnam.

Widespread shrub species form a more or less dense scrub along the beaches, on dunes, marine terraces and on sea slopes. Common species here are: *Scaevola koenigii* (*Goodeniaceae*), *Cerbera manghas* (*Apocynaceae*), *Pandanus tectorius* (*Pandanaceae*), *Cycas rumphii*, *C. inermis* (*Cycadaceae*), *Caesalpinia godefroyana* (*Fabaceae*), *Clerodendron inerme* (*Verbenaceae*), *Litchi longana* (*Sapotaceae*), *Pleiospermium littorale* (*Rutaceae*), *Sindora siamensis* (*Fabaceae*), *Vitex trifolia* (*Verbenaceae*) and others (Schmid 1974; Averyanov *et al.* 1988).

Baekkea frutescens, *Melaleuca leucadendron* (*Myrtaceae*), *Acronychia laurifolia* (*Rutaceae*), *Canthium didymum* (*Rubiaceae*), *Alstonia spathulata* (*Apocynaceae*), numerous grasses and sedges occupy moist depressions and coastal wetlands along low dunes.

Extensive stands of mangroves are common in Vietnam around deltas of large rivers and on swampy brackish coastal lowlands (Fig. 3). Mangrove diversity in the country is relatively high. The most common species occurring here are *Avicennia alba*, *A. officinalis* (*Verbenaceae*), *Lumnitzera racemosa*, *L. littorea* (*Combretaceae*), *Bruguiera gymnorrhiza*, *B. sexangula*, *Ceriops tagal*, *Kandelia candel*, *Rhizophora apiculata*, *Rh. mucronata*, *Rh. stylosa* (*Rhizophoraceae*), *Sonneratia caseolaris* (*Sonneratiaceae*), as well as typical mangrove palms – *Nypa fruticans* and *Phoenix paludosa*.

No (or very few) orchid species are typically found in lowland coastal habitats.

6.7. Secondary and agricultural plant communities (including tree plantations)

Various secondary forests, secondary formations of thickets, scrublands and grasslands have developed under the long history of human impact on native vegetation. Such plant communities along with agricultural areas, timber and industrial plantations now cover vast areas of the country

(Fig. 3). Plant communities within these areas contain many weedy and exotic species at the expense of all native species.

A few orchids, such as *Arundina graminifolia*, *Phaius tankervilleae*, *Spiranthes sinensis*, *Zeuxine strateumatica*, some species of *Geodorum*, *Habenaria*, *Nervilia* and *Peristylus* are occasionally capable of surviving in secondary plant communities. These species represent a very small group in comparison with the orchid flora of primary habitats of these areas in the past.

7. Main floristic regions of the area

The most commonly cited system of floristic classification, developed by Takhtajan (1978, 1986), defines six kingdoms, or realms at the highest category in a hierarchy of floristic divisions of the world. They are distinguished on the basis of the presence of endemic taxa of the highest rank — families, subfamilies and tribes. The six kingdoms or realms in this floristic classification are the Holarctic, Paleotropical, Neotropical, Cape, Australian and Holantarctic Kingdoms.

South-East Asia lies within the Paleotropical Kingdom covering most of the Old World tropics with the exception of Australia. This vast and highly diverse area is further divided into 5 subkingdoms: African, Madagascan, Indomalesian, Polynesian and Neocaledonian. Among them the Indomalesian Subkingdom includes the broad territory of the Indian subcontinent and South-East Asia. Takhtajan (1978, 1986) characterizes this subkingdom by its remarkably high levels of endemism including 16 endemic families of vascular plants and a great number of endemic genera and species. He states that no other floristic unit in the world contains so many ancient and archaic forms of flowering plants.

The Indomalesian Subkingdom is divided into 4 floristic regions: Indian, Indochinese, Malesian and Fijian. The vast majority of Vietnam and eastern Indochina belongs to Indochinese Floristic Region. The Indochinese Floristic Region extends from the southeastern and eastern border areas of Bangladesh to the tropical regions of eastern India across Myanma and Thailand to Laos, Cambodia and Vietnam including Andaman Islands, tropical regions of southwestern and southern China, and Hainan Island. The smaller mountain areas of northern Vietnam, Laos and Thailand are placed into the Eastern Asiatic Region of the Holarctic Kingdom. Within Takhtajan's floristic system the Indochinese Floristic Region is subdivided into 7 units, the South Burmese, Andamanese, South Chinese, Thaiandian, North Indochinese, South Indochinese and Annamese Provinces. Based on data from modern floristic studies, the Annamese province may now be further divided into 2 well-defined floristic units — the Central Annamese and South Annamese Provinces.

Six clear floristic units may be outlined within the territory of Vietnam and adjacent areas of the eastern part of the Indochinese Peninsula on the basis of present phytogeographic, geological, geomorphologic and climatological data. Some preliminary boundaries of these areas as floristic provinces were outlined in the general floristic division of Takhtajan (1978, 1986). Recent studies can further clarify these limits in more detail. These newly defined floristic provinces with more or less detailed boundaries presented here are named the Sikang–Yunnan, South Chinese, North Indochinese, Central Annamese, South Annamese and South Indochinese Provinces, as shown in figure 3.

7.1. Sikang–Yunnan Province

The largest part of this province lies within China and includes the "Himalayan", "Henduan Mountain" and "Yunnan plateau" regions proposed by Wu Zhengyi and Wu Sugong (1998) in their preliminary floristic division of China. This area coincides with the southwestern section of the Sino-Japanese floristic region of Good (1964). Geographically the Sikang–Yunnan Province as defined here encompasses a large part of western Sichuan, the Yunnan Plateau, and the bordering regions of the mountains of northeastern Myanma, northern Laos and northwestern Vietnam (Takhtajan 1978, 1986).

In Vietnam, within this floristic province lie the highland regions of Lai Chau, Lao Cai and Yen Bai administrative provinces as well as the high granite mountain massifs Tay Con Linh and Pu Tha Ca situated in Ha Giang Province very near the border with China. Within Laos the Sikang–Yunnan Province enters Phong Sali administrative province. In general the southern limit of this floristic province occurs at about 800–1200 m a.s.l. (Fig. 3). Some larger isolated silicate mountain systems like Tam Dao, Pia Da or Pia Oac that are a little to the east outside the boundaries of the Sikang–Yunnan Province have clear floristic relationships with this province, while situated within the territory of the South Chinese Province.

Generally, Sikang–Yunnan Province encompasses a vast montane area, which geographically represents the SSE extension of the Himalayan highlands. Its southern portion extends to Vietnam and includes a number of higher elevation mountain ranges including Hoang Lien Son, Si Lung, Den Dinh etc., which extend generally from the northwest to southeast. These contiguous highlands form a clearly outlined region and include large areas above 1500–2000 m. Some peaks here reach 2500–3000 m or more. Among these higher peaks are Fan Si Pan (3143 m), Ta Giang Pinh (3096 m), Si Lung (3076 m), Luong (2985 m), Phoung Chang (2825 m), Lang Kung (2817 m) and many others. Mountain systems here are generally composed of silicate rocks, mainly granite, gneiss, rhyolite or quartzite, formed as extensive magmatic intrusions of late Paleozoic and Mesozoic ages (Dovzikov *et al.* 1965a, b). Tertiary tectonic movements uplifted these montane terrains to modern elevations and further erosion formed the present characteristic rocky landscape of this highland area (Schzeglova 1957; Rundel 1999).

There are scant data available on climate within the Vietnamese part of the Sikang–Yunnan Province. Climate across the vast majority of the floristic province territory is defined as monsoon tropical climate associated with mountains (Nguyen Khanh Van *et al.* 2000). This territory experiences a humid climate with warm rainy summers and cold foggy and misty winters without a distinct dry period (Fig. 1). Mean annual rainfall here averages approximately 2000–3500 mm (Fig. 2). Summer temperatures in the Vietnamese portion of the Sikang–Yunnan Province are around 16–20° C and the winter mean temperature normally varies between 7–10° C. The absolute minimum temperature reported at 2170 m a.s.l. is –5.7° C. Snow, sleet, hail often mixed with rain are not uncommon during winter months at altitudes above 2000 m a.s.l.

Considerable temperature variations connected with higher altitude encourage the formation of a distinct zonation of vegetation in the Vietnamese portion of the Sikang–Yunnan Province. Evergreen broad-leaved or mixed wet closed montane forests are the dominant primary types of vegetation in the area.

At lower elevations, especially along deep river valleys below 700 m a.s.l., the broad-leaved montane forests begin to acquire a more typical character of montane tropical forests including tropical representatives of *Fagaceae*, *Fabaceae*, *Sapindaceae*, *Burseraceae*, *Meliaceae*, *Magnoliaceae*, *Lauraceae* and *Anacardiaceae* as dominants of the first forest stratum (Nguyen Nghia Thin 1998; Nguyen Nghia Thin & Nguyen Thi Thoi 1998). In fact, these forests, situated in the southern parts of the Sikang–Yunnan Province, represent the altitudinal and latitudinal limits of typical tropical forests and define the northern margin of the tropical zone within the mountainous areas of northwestern Vietnam and northern Laos (Fig. 3). Along low valleys of large rivers the complexes of tropical flora penetrate as far north as China. This gives some basis for drawing the border of the tropical zone on Chinese territory along the Laos and Vietnamese boundaries (Wu Zhengyi & Wu Sugong 1998).

At elevations between 1000–2000 m a.s.l., the primary vegetation observed in the Vietnamese portion of the Sikang–Yunnan Province is evergreen broad-leaved subtropical forest. It is distinguished from tropical rain forest by the less tall largest trees, the continuous closed canopies of the upper stratum (without emergent trees), the lack of buttresses, cauliflory and the absence of large woody lianas (Nguyen Nghia Thin 1998; Nguyen Nghia Thin & Nguyen Thi Thoi 1998). Typical highland species of *Aceraceae*, *Betulaceae*, *Elaeocarpaceae*, *Fagaceae*, *Hamamelidaceae*, *Lauraceae*, *Magnoliaceae*, *Sapotaceae* and *Theaceae* are main dominants in these forests (Nguyen

Nghia Thin 1998). The subtropical nature of this montane belt is indicated by the common presence of species and genera such as *Hydrangea* (*Hydrangeaceae*), *Kadsura*, *Schizandra* (*Schizandraceae*), *Buddleja* (*Buddlejaceae*), *Cornus* (*Cornaceae*), *Adinandra*, *Anneslea*, *Gordonia*, *Pyrenaria* (*Theaceae*), *Exbucklandia*, *Rhodoleia*, *Liquidambar* (*Hamamelidaceae*), *Alcimandra*, *Liriodendron*, *Manglietia*, *Magnolia* (*Magnoliaceae*) and many others. At the same time numerous representatives of families having obvious tropical affinities commonly enter elevations of 1500–2000 m a.s.l. Among them are species of *Annonaceae*, *Araceae*, *Arecaceae*, *Balanophoraceae*, *Clusiaceae*, *Combretaceae*, *Ebenaceae*, *Euphorbiaceae*, *Gnetaceae*, *Hernandiaceae*, *Iacinaceae*, *Melastomataceae*, *Moraceae*, *Proteaceae* and *Rubiaceae*, as well as large woody ferns (*Cyatheaceae*). These areas exhibit the clear transitional nature within these forests from tropical to subtropical types of vegetation.

The analogue of the temperate primary vegetation is found in the Vietnamese portion of the Sikang–Yunnan Province at elevations above 2000 m a.s.l. These montane temperate forests (Nguyen Nghia Thin 1998; Nguyen Nghia Thin & Nguyen Thi Thoi 1998) are characterized by representatives of *Abies*, *Tsuga* (*Pinaceae*), *Acer* (*Aceraceae*), *Aesculus* (*Hippocastanaceae*), *Alnus*, *Betula* (*Betulaceae*), *Celtis*, *Ulmus* (*Ulmaceae*), *Cornus* (*Cornaceae*), *Castanea*, *Fagus*, deciduous *Quercus* (*Fagaceae*), *Platycarya* (*Juglandaceae*), *Liriodendron*, *Magnolia* (*Magnoliaceae*), *Rhododendron* (*Ericaceae*), *Sorbus* (*Rosaceae*) and other kinds of trees more or less typical of more temperate floras. Typical climatic conditions in these forests are heavy rainfall, a low rate of evaporation, low temperatures and strong winds, which restrict plant growth. Most of the trees are very short, gnarled, twisted and often multi-stemmed. Mosses and lichens cover the branches, trunks and even the forest floor while epiphytic ferns and orchids are also quite common.

Extensive anthropogenic destruction of primary vegetation and deforestation throughout the area has resulted in the formation of various types of secondary plant communities. These have been classified and named by various authors as savannas, subtropical savannas, montane grasslands, montane cold savannas, scrub savannas, grass savannas and even steppe meadows (Khoang Tjyung 1988; Nguyen Nghia Thin 1998; Nguyen Nghia Thin & Nguyen Thi Thoi 1998). These types of anthropogenic open secondary plant communities commonly lack native timber species. At the same time the formation of secondary highland short and tall grasslands often promotes extensive invasion by herbaceous, semi-weedy temperate species and increases the probability of fire.

The flora of the Sikang–Yunnan Province is very rich and diverse. It includes a large variety of endemic genera and a great number of endemic species (Takhtajan 1978, 1986). About 15.3% of Vietnamese endemics occur in the Vietnamese portion of the Sikang–Yunnan Province. Local endemism of species is estimated here as 5.7% (Fig. 4). Some of these local plant endemics are reported for the following selected families:

Annonaceae (*Cyathostemma vietnamense*,
Enicosanthellum petelotii),
Apiaceae (*Hydrocotyle chevalieri*,
H. petelotii),
Araliaceae (*Aralia chapaensis*, *Brassaiopsis*
gaussenii, *Dendropanax petelotii*,
Pentapanax verticillatus, *Schefflera*
alpina, *Sch. brevipedicellata*,
Sch. chapana, *Sch. enneaphylla*,
Sch. fantsipanensis, *Sch. macrophylla*,
Sch. membranifolia, *Sch. myriocarpa*,
Sch. vietnamensis),
Cornaceae (*Cornus gigantea*,
C. oligophlebia, *C. tonkinensis*),

Euphorbiaceae (*Macaranga henryi*),
Fabaceae (*Acacia pruinescens*),
Hamamelidaceae (*Altingia poilanei*),
Myrsinaceae (*Ardisia botryosa*,
A. perpendicularis, *A. prionota*, *Embelia*
acuminata, *E. polypodioides*, *Maesa*
reticulata, *Rapanea cicatricosa*,
R. verruculosa),
Passifloraceae (*Passiflora celata*),
Primulaceae (*Lysimachia chapaensis*,
L. fooningensis, *Primula cardioeides*,
P. chapaensis, *P. petelotii*),
Proteaceae (*Helicia grandis*, *H. petelotii*),

Rosaceae (*Rubus etropicus*, *R. idaeifolius*,
R. intermittens, *R. involucris*,
R. ochraceus, *R. ovatus*, *R. tonkinensis*,
Sorbus ligustrifolia, *Stranvaesia*
microphylla),
Sabiaceae (*Meliosma petelotii*,
M. sterrophylla, *M. tonkinensis*),

Scrophulariaceae (*Brandisia glabrescens*,
Mazus henryi, *Pedicularis petelotii*),
Smilacaceae (*Smilax petelotii*),
Theaceae (*Adinandra megaphylla*,
Pyrenaria cheliensis, *Stuartia*
pterotiolata, *Ternstroemia chapaensis*),
Thymelaeaceae (*Daphne bholuta*).

About 117 orchid species from 46 genera are known in the Vietnamese part of the Sikang–Yunnan Province. Among them a monotypic genus *Hancockia* and 11 local endemics, as reported in Table 4.

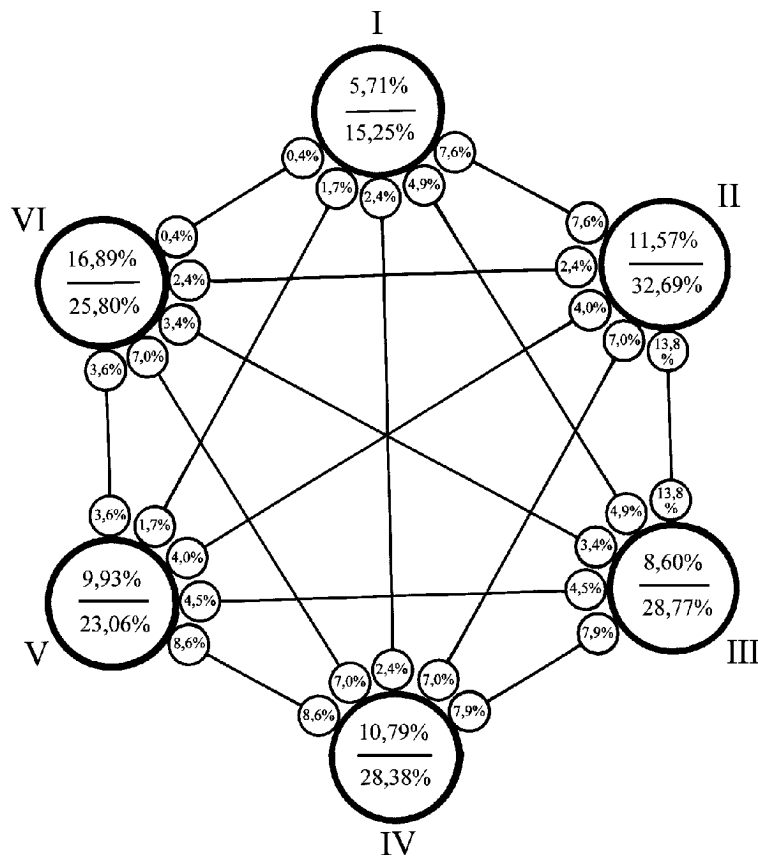


Fig. 4. Scheme of relationships of the floristic provinces on the basis of analysis of the local endemism of vascular plants in the area (the number of endemic species for selected families occurring in Vietnamese portions of the provinces is taken as 100%).

Large rings designate floristic regions: I – Sikang–Yunnan; II – South Chinese; III – North Indochinese; IV – Central Annamese; V – South Annamese; and VI – South Indochinese Provinces. Percentage numbers above the line in the large rings denote the relative proportion of strict endemics occurring only in a certain province (within Vietnam); percentage numbers below the line denote the relative proportion of Vietnamese endemics occurring in a certain province. Percentage numbers in the small rings denote the relative proportion of Vietnamese endemics occurring in the pairs of provinces connected by the line and show their relative floristic relationships.

Table 4. Orchid species reported from the Vietnamese portion of the Sikang–Yunnan Province (local endemics of this area in bold)

<i>Amitostigma keiskeoides</i> ,	<i>Dendrobium alleizettii</i> ,	<i>L. bootanensis</i> ,
<i>Anoectochilus brevistylus</i> ,	<i>D. aphyllum</i> ,	<i>L. cespitosa</i> ,
<i>A. chapaënsis</i> ,	<i>D. chlorostylum</i> ,	<i>L. chapaënsis</i> ,
<i>A. lanceolatus</i> ,	<i>D. chryseum</i> ,	<i>L. cordifolia</i> ,
<i>A. roxburghii</i> ,	<i>D. devonianum</i> ,	<i>L. deflexa</i> ,
<i>A. siamensis</i> ,	<i>D. henryi</i> ,	<i>L. dendrochiloides</i> ,
<i>Anthogonium gracile</i> ,	<i>D. longicornu</i> ,	<i>L. latilabris</i> ,
<i>Apostasia odorata</i> ,	<i>D. sociale</i> ,	<i>L. paradoxa</i> ,
<i>Arundina graminifolia</i> ,	<i>Diplomeris pulchella</i> ,	<i>L. penduliflora</i> ,
<i>Bulbophyllum ambrosia</i> ,	<i>Epigeneium amplum</i> ,	<i>L. petelotii</i> ,
<i>B. andersonii</i> ,	<i>E. chapaënsis</i> ,	<i>L. petiolata</i> ,
<i>B. emarginatum</i> ,	<i>Eria apertiflora</i> ,	<i>L. plantaginea</i> ,
<i>B. flabellovenaris</i> ,	<i>E. bambusifolia</i> ,	<i>Ludisia discolor</i> ,
<i>B. insulsum</i> ,	<i>E. boniana</i> ,	<i>Mischobulbum macranthum</i> ,
<i>B. reptans</i> ,	<i>E. clausa</i> ,	<i>Oberonia ensiformis</i> ,
<i>B. retusiusculum</i> ,	<i>E. corneri</i> ,	<i>O. falcata</i> ,
<i>B. schweliense</i> ,	<i>E. coronaria</i> ,	<i>O. variabilis</i> ,
<i>Calanthe alleizettei</i> ,	<i>E. gagnepainii</i> ,	<i>Otochilus albus</i> ,
<i>C. alismifolia</i> ,	<i>E. globulifera</i> ,	<i>Paphiopedilum gratrixianum</i> ,
<i>C. angusta</i> ,	<i>E. lanigera</i> ,	<i>P. hirsutissimum</i> ,
<i>C. densiflora</i> ,	<i>E. siamensis</i> ,	<i>P. villosum</i> ,
<i>C. herbacea</i> ,	<i>E. simondii</i> ,	<i>Peristylus aristatus</i> ,
<i>C. manni</i> ,	<i>Eulophia spectabilis</i> ,	<i>P. calcaratus</i> ,
<i>C. petelotiana</i> ,	<i>Galeola nudifolia</i> ,	<i>P. chapaënsis</i> ,
<i>Callostylis rigida</i> ,	<i>Gastrochilus pseudodistichus</i> ,	<i>P. constrictus</i> ,
<i>Cephalantheropsis longipes</i> ,	<i>Gastrodia taiensis</i> ,	<i>P. prainii</i> ,
<i>C. obcordata</i> ,	<i>Goodyera foliosa</i> ,	<i>P. tentaculatus</i> ,
<i>Ceratostylis siamensis</i> ,	<i>G. procera</i> ,	<i>Pholidota roseans</i> ,
<i>Cleisostoma chapaënsis</i> ,	<i>G. schlechtendaliana</i> ,	<i>Platanthera angustata</i> ,
<i>C. inflatum</i> ,	<i>Habenaria arietina</i> ,	<i>Pleione grandiflora</i> ,
<i>C. rostratum</i> ,	<i>H. dentata</i> ,	<i>P. maculata</i> ,
<i>Coelogyne rigida</i> ,	<i>H. limprichtii</i> ,	<i>Podochilus microphyllus</i> ,
<i>Collabium chapaënsis</i> ,	<i>H. malintana</i> ,	<i>Sarcoglyphis smithianus</i> ,
<i>Corymborkis veratrifolia</i> ,	<i>H. pantlingiana</i> ,	<i>Spathoglottis pubescens</i> ,
<i>Cremastra appendiculata</i> ,	<i>H. petelotii</i> ,	<i>Spiranthes sinensis</i> ,
<i>Cryptochilus lutea</i> ,	<i>Hancockia uniflora</i> ,	<i>Thecostele alata</i> ,
<i>Cymbidium ensifolium</i> ,	<i>Herminium lanceum</i> ,	<i>Thunia alba</i> ,
<i>C. insigne</i> ,	<i>Holcoglossum lingulatum</i> ,	<i>Trichotosia dasyphylla</i> ,
<i>C. lancifolium</i> ,	<i>Liparis averyanoviana</i> ,	<i>T. pulvinata</i> ,
<i>C. lowianum</i> ,	<i>L. balansae</i> ,	<i>Vanda liouvillei</i> .

The orchid flora of the Sikang–Yunnan Province is much richer than that reported only within the limits of Vietnam. A great number of endemic orchids occur in this Floristic Province including such outstanding local endemics as *Paphiopedilum armeniacum*, *P. tigrinum* and *P. wardii*.

Along with the occurrence of diverse typical tropical timber and forest species, in a number of deep river valleys within the southern portion of the province, a considerable number of temperate floristic elements at higher elevations are typical of the highlands of the Sikang–Yunnan

Province. Notable among them are the following families and genera (Nguyen Nghia Thin 1998; Nguyen Nghia Thin & Nguyen Thi Thoi 1998):

<i>Aceraceae</i> (<i>Acer</i>),	<i>Juncaceae</i> (<i>Juncus</i> , <i>Luzula</i>),
<i>Araliaceae</i> (<i>Panax</i>),	<i>Lamiaceae</i> (<i>Ajuga</i> , <i>Clinopodium</i> , <i>Leonurus</i> ,
<i>Asteraceae</i> (<i>Achillea</i> , <i>Gnaphalium</i> ,	<i>Prunella</i> , <i>Scutellaria</i> , <i>Stachys</i>),
<i>Leontopodium</i> , <i>Senecio</i> , <i>Sonchus</i> ,	<i>Lentibulariaceae</i> (<i>Utricularia</i>),
<i>Taraxacum</i>),	<i>Onagraceae</i> (<i>Circaea</i> , <i>Epilobium</i>),
<i>Betulaceae</i> (<i>Alnus</i> , <i>Betula</i> , <i>Carpinus</i>),	<i>Plantaginaceae</i> (<i>Plantago</i>),
<i>Boraginaceae</i> (<i>Cynoglossum</i>),	<i>Poaceae</i> (<i>Agrostis</i> , <i>Calamagrostis</i> ,
<i>Brassicaceae</i> (<i>Capsella</i> , <i>Cardamine</i>),	<i>Digitaria</i> , <i>Eragrostis</i> , <i>Poa</i>),
<i>Caryophyllaceae</i> (<i>Cerastium</i> , <i>Cucubalus</i> ,	<i>Podophyllaceae</i> (<i>Podophyllum</i>),
<i>Myosoton</i> , <i>Sagina</i> , <i>Stellaria</i>),	<i>Polygonaceae</i> (<i>Fallopia</i> , <i>Persicaria</i> ,
<i>Convallariaceae</i> (<i>Polygonatum</i>),	<i>Rheum</i>),
<i>Cornaceae</i> (<i>Cornus</i>),	<i>Primulaceae</i> (<i>Primula</i> , <i>Lysimachia</i>),
<i>Crassulaceae</i> (<i>Rhodiola</i> , <i>Sedum</i>),	<i>Ranunculaceae</i> (<i>Aconitum</i> , <i>Anemone</i> ,
<i>Cyperaceae</i> (<i>Eriophorum</i> , <i>Rhynchospora</i> ,	<i>Ranunculus</i> , <i>Thalictrum</i>),
<i>Scirpus</i>),	<i>Rosaceae</i> (<i>Agrimonia</i> , <i>Fragaria</i> , <i>Geum</i> ,
<i>Dipsacaceae</i> (<i>Dipsacus</i>),	<i>Potentilla</i> , <i>Rosa</i> , <i>Sorbus</i> , <i>Photinia</i>),
<i>Ericaceae</i> (<i>Rhododendron</i> , <i>Vaccinium</i>),	<i>Scrophulariaceae</i> (<i>Pedicularis</i>),
<i>Fabaceae</i> (<i>Astragalus</i>),	<i>Rubiaceae</i> (<i>Galium</i> , <i>Rubia</i>),
<i>Fagaceae</i> (<i>Fagus</i> , <i>Castanea</i> , <i>Quercus</i>),	<i>Saxifragaceae</i> (<i>Astilbe</i> , <i>Saxifraga</i>),
<i>Gentianaceae</i> (<i>Gentiana</i> , <i>Swertia</i>),	<i>Ulmaceae</i> (<i>Ulmus</i>),
<i>Hippocastanaceae</i> (<i>Aesculus</i>),	<i>Valerianaceae</i> (<i>Patrinia</i> , <i>Valeriana</i>),
<i>Juglandaceae</i> (<i>Platycarya</i>),	<i>Violaceae</i> (<i>Viola</i>).

Such orchids as *Amitostigma keiskeoides*, *Cremastra appendiculata*, *Gastrodia taiensis*, *Goodyera foliosa*, *G. schlechtendaliana*, *Hancockia uniflora*, *Platanthera angustata*, *Pleione grandiflora* and *P. maculata* also belong to this group of species having temperate relations.

The large representation of species with obvious subtropical and temperate distribution within these highland plant communities of the southern portion of the Sikang–Yunnan Province supports its Holarctic character as an extreme southern extension of the Holarctic floristic kingdom (Takhtajan 1978, 1986).

7.2. South Chinese Province

Within this province lie the tropical regions of southeastern China, including the lowland, extreme southeastern areas of Yunnan, south and southwestern regions of Guangxi, the coastal areas from Nanning to Macao, the Luichow Peninsula, the island of Hainan, and the northeastern portion of Vietnam (Takhtajan 1978, 1986). The Chinese portion of this area includes "Tonkin Bay" and "South China Sea" regions, as well as the southern extremity of "Yunnan, Guizhou & Guangxi limestone mountain & hill region" as proposed in the floristic division of China by Wu Zhengyi and Wu Sugong (1998). Its northern border coincides approximately with the limit dividing the "Sino-Japanese" and "Continental South-East Asiatic" regions of Good (1964). The southwestern limit of the South Chinese Province coincides with the deep and wide Song Hong (Red River) valley that follows the major Cenozoic rift zone separating the South China and South-East Asian plates. In Vietnam, Ha Giang, Cao Bang, Tuyen Quang, Bac Kan, Lang Son, Thainguyen, Bac Giang, Quang Ninh, Bac Ninh, Hai Duong, Hung Yen, Thai Binh, the area of Hai Phong city, the north-eastern portions of Lao Cai, Yen Bai, Vinh Phuc Provinces and the north-eastern part of Hanoi administrative area belong to the South Chinese floristic province (Fig. 3). This floristic province also encompasses the islands of the northeastern part of Bac Bo (Tonkin) Gulf.

Geologically this area represents the south extremity of the ancient solid structural block known as the South China Platform, geographically comprising eastern Yunnan, southern Kweichow (Guizhou), western Guangxi Provinces of China and the northeastern portion of Vietnam. Considerable uplifts and subsidence are typical of this area during its geologic history. This area experienced relatively little deformation and orogenic folding. The Vietnamese portion of the South Chinese floristic province is mostly mountain or hilly country with relatively broad and low mountain ranges including the Song Gam, Ngan Son, Bac Son and Dong Trieu. These ranges of mountains are oriented north to south and northeast to southwest. Highly metamorphosed and deeply eroded marine sediments of late Paleozoic or early Mesozoic ages have formed vast areas of landscapes within this region (Dovzikov *et al.* 1965b; Rundel 1999). Very often these sediments are solid marble-like limestone that have been uplifted and highly eroded forming narrow remnant ridges, table-like mountains and column-like mesae with numerous vertical bluffs and cliffs. Deep caves, sinkholes, karstic lakes and rivers that disappear during dry season, create the unique characteristics of these limestone areas of this floristic province. Elevations here are about 300–700 m, however some limestone mountains in the north may reach 1400–1600 m a.s.l.

Evergreen, broad-leaved tropical forests with tropical dominants are typical of lowland areas of the province. Mixed and coniferous forests developed on highly eroded, rocky limestone mountains represent the most characteristic floristic vegetation within the South-China Province. Main dominants in these floristically richest forests are subendemic coniferous trees — *Pinus kwangtungensis*, *Pseudotsuga brevifolia* and *Tsuga chinensis* (Nguyen Tien Hiep 1998; Phan Ke Loc *et al.* 1999a; Averyanov *et al.* 2000). Other rare gymnosperm species like *Amenthotaxus argotaenia*, *A. hatuyensis*, *A. yunnanensis*, *Cupressus torulosa*, *Fokienia hodginsii*, *Keteleeria davidiana*, *Nageia fleurii*, *N. wallichiana*, *Podocarpus brevifolius*, *P. neriifolius*, *P. pilgeri*, *Taxus chinensis*, *Xanthocyparis vietnamensis* are also more or less regular components of limestone forests within the Vietnamese part of the South-Chinese Province (Nguyen Tien Hiep & Vidal 1996; Nguyen Tien Hiep 1998; Phan Ke Loc *et al.* 1999a, b, c; Vu Van Can *et al.* 1999a, b).

The highest mountains within the Vietnamese part of the South-Chinese floristic province were formed by magmatic intrusions of late Paleozoic and Mesozoic ages (Dovzikov *et al.* 1965b; Rundel 1999). These mountain systems are composed most often of silicate rocks such as granite, rhyolite and quartzite. These more or less isolated mountain systems lie mainly along the Chinese border and include Pia Da (1980 m), Pia Oac (1930 m), Cham Chu (1587 m) and many others. Relatively short silicate ridges like Pia Bioc (1578 m), Nui Con Voi (1450 m) and Tam Dao (1591 m) tower in the central areas of the Vietnamese portion of the South-Chinese floristic province. Very wet, closed, broad-leaved evergreen forests are typical of mountains composed of silicate rocks. The taxonomic composition of these forests has affinities with the montane forests of the southern part of Sikang–Yunnan Province. Sometimes they support a very rich orchid flora as was observed years ago in Tam Dao Ridge. However within this area the orchid flora usually becomes less rich at elevations above 1200–1300 m a.s.l. due to too low winter temperatures.

Climate patterns within the Vietnamese part of the South-Chinese floristic province are classified as a monsoon tropical climate with cold winter and summer rains (Nguyen Khanh Van *et al.* 2000). Very humid, hot summers with torrential rains and dry winters are typical of the area (Fig. 1). In most regions of the province mean annual rainfall varies from 1000 to 2500 mm (Fig. 2). However, at higher elevations and within specific orogenetic microclimates the mean annual rainfall may rise locally up to 4802 mm (Bac Quang town) with annual absolute maximum of 6466 mm (Nguyen Khanh Van *et al.* 2000; Nguyen Khanh Van, pers. comm.). Common summer temperatures in the area are around 25–30° C, with winter temperatures normally between 15–20° C. Night temperature during the coldest winter nights may drop to below 0° C at elevations above 900–1000 m a.s.l. Cold foggy and misty weather during March — early April is very typical of lowland regions of the province near the sea.

The flora of the South-Chinese floristic province is very rich and specific. A remarkably high level of endemism is especially typical of limestone mountain areas representing the highly specialized sclerophytic derivatives that evolved on deeply eroded, ancient, solid limestone. A number of endemic and subendemic genera such as *Cathayanthus*, *Chaydaia*, *Chunia*, *Dasydesmus*, *Eberhardtia*, *Graphistemma*, *Grushvitzkia*, *Guihaia*, *Hainania*, *Paedicalyx*, *Raphiocarpus*, *Sapindopsis*, *Sinosideroxylon*, *Thysanosperrum*, *Wenchengia*, *Xanthocyparis* and *Xanthophytopsis* are reported for this province (Takhtajan 1986; Skvortsova & Averyanov 1994; Wu Zhengyi & Wu Sugong 1998; Averyanov *et al.* 2002). Approximately 32.7% of Vietnamese endemics occur in the Vietnamese portion of the South-Chinese Province. Among them 11.6% are local endemics with ranges limited by the boundary of the Vietnamese portion of the South-Chinese floristic province (Fig. 4). They are reported for selected families below:

- Anacardiaceae* (*Dracontomelon petelotii*, *Semecarpus tonkinensis*),
Annonaceae (*Artabotrys petelotii*, *A. vietnamensis*, *Fissistigma cupreonitens*, *F. tonkinense*, *Goniothalamus chartaceus*, *G. takhtajanii*, *G. vietnamensis*, *Uvaria boniana*, *U. pachychila*),
Apiaceae (*Hydrocotyle tonkinensis*),
Araceae (*Alocasia decumbens*, *Amorphophallus hayi*, *Scindapsus megaphyllus*),
Araliaceae (*Dendropanax bilocularis*, *Grushvitzkia stellata*, *Macropanax sessilis*, *Schefflera fasciculifoliolata*, *Sch. kornasii*, *Sch. lociana*),
Bignoniaceae (*Radermachera stellata*),
Cucurbitaceae (*Trichosanthes pedata*),
Cupressaceae (*Thuja quanbaensis*),
Cycadaceae (*Cycas balansae*, *C. diannanensis*, *C. taiwaniana*),
Dipterocarpaceae (*Hopea chinensis*, *H. mollissima*),
Euphorbiaceae (*Alchornea androgyna*, *A. petelotii*, *Breynia rostrata*, *B. tonkinensis*, *Croton eberhardtii*, *C. langsonensis*, *C. pontis*, *Macaranga sampsonii*, *M. trigonostemonoides*, *Mallotus microcarpus*, *Phyllanthus anthopotamicus*, *Ph. balansae*, *Ph. discofractus*, *Ph. dongmoensis*, *Ph. petelotii*, *Sauropus tiepii*, *Trigonostemon stellaris*, *T. tranii*),
Fabaceae (*Archidendron tonkinense*, *A. utile*, *Bauhinia carcinophylla*, *B. corymbosa*, *B. pyrroclada*, *Caesalpinia rhombifolia*, *C. sinensis*, *Dalbergia dyeriana*, *D. hainanensis*, *D. hancei*, *D. henryana*, *D. tonkinensis*, *Gymnocladus angustifolia*, *Lysidice rhodostegia*, *Ormosia emarginata*, *O. inflata*, *O. tsangii*, *O. simplicifolia*),
Flacourtiaceae (*Bennettiodendron cordatum*, *Homalium mollissimum*, *H. petelotii*, *Hydnocarpus hainanensis*),
Hamamelidaceae (*Embolanthera glabrescens*),
Loganiaceae (*Strychnos cathayensis*),
Moraceae (*Artocarpus styracifolius*, *Ficus pubilimba*),
Myrsinaceae (*Ardisia maclurei*, *A. pedalis*, *A. villosula*, *Maesa ambigua*),
Nyssaceae (*Nyssa sinensis*),
Passifloraceae (*Passiflora eberhardtii*),
Pinaceae (*Pseudotsuga brevifolia*),
Rosaceae (*Rubus feddei*),
Sabiaceae (*Meliosma caudata*, *M. doliobotrys*, *M. longipaniculata*, *Sabia uropetala*),
Sapotaceae (*Eberhardtia tonkinensis*, *Madhuca hainanensis*, *M. subquincuncialis*, *Sarcosperma angustifolium*, *S. laurinum*, *Sinosideroxylon wrightii*, *Xantolis embeliifolia*),
Scrophulariaceae (*Lindernia longituba*),
Styracaceae (*Huodendron parvifolium*),
Symplocaceae (*Symplocos dolichotricha*, *S. groffii*, *S. olivacea*),
Taxaceae (*Amentotaxus hatuyenensis*),
Theaceae (*Adinandra lienii*, *Camellia aurea*, *C. forrestii*, *C. gracilipes*, *C. indochinensis*, *C. lianshanensis*, *Ternstroemia kwangtungensis*).

About 296 orchid species from 88 genera are known within this territory. Among them are 42 local endemics, reported in Table 5.

Table 5. Orchid species reported from the Vietnamese portion of the South-Chinese floristic province (local endemics of this area in bold)

<i>Acampe rigida</i> ,	<i>C. herbacea</i> ,	<i>D. faulhaberianum</i> ,
<i>Acanthephippium simplex</i> ,	<i>C. mannii</i> ,	<i>D. fimbriatum</i> ,
<i>A. striatum</i> ,	<i>C. triplicata</i> ,	<i>D. gibsonii</i> ,
<i>Adenoncos vesiculosa</i> ,	<i>C. rigida</i> ,	<i>D. henryi</i> ,
<i>Aerides odorata</i> ,	<i>Cephalantheropsis obcordata</i> ,	<i>D. lindleyi</i> ,
<i>Ae. rosea</i> ,	<i>Ceratostylis himalaica</i> ,	<i>D. linguella</i> ,
<i>Anoectochilus calcareus</i> ,	<i>C. tonkinensis</i> ,	<i>D. lituiflorum</i> ,
<i>A. elwesii</i> ,	<i>Cheirostylis bipunctata</i> ,	<i>D. loddigesii</i> ,
<i>A. lylei</i> ,	<i>C. chinensis</i> ,	<i>D. longicornu</i> ,
<i>A. roxburghii</i> ,	<i>C. marmorifolia</i> ,	<i>D. mitratum</i> ,
<i>A. sikkimensis</i> ,	<i>C. takeoi</i> ,	<i>D. nobile</i> ,
<i>A. tridentatus</i> ,	<i>C. thanmoiensis</i> ,	<i>D. ochreatum</i> ,
<i>Apostasia odorata</i> ,	<i>C. yunnanensis</i> ,	<i>D. parishii</i> ,
<i>Appendicula cornuta</i> ,	<i>Cleisostoma aspersum</i> ,	<i>D. porphyrochilum</i> ,
<i>Arachnis labrosa</i> ,	<i>C. birmanicum</i> ,	<i>D. salaccense</i> ,
<i>Arundina chinensis</i> ,	<i>C. crochetii</i> ,	<i>D. truncatum</i> ,
<i>A. graminifolia</i> ,	<i>C. fuerstenbergianum</i> ,	<i>Diplopropa championii</i> ,
<i>Biermannia calcarata</i> ,	<i>C. paniculatum</i> ,	<i>Dipodium paludosum</i> ,
<i>Bletilla ochracea</i> ,	<i>C. rostratum</i> ,	<i>Epigeneium amplum</i> ,
<i>Bulbophyllum affine</i> ,	<i>C. scortechinii</i> ,	<i>E. chapaense</i> ,
<i>B. ambrosia</i> ,	<i>C. striatum</i> ,	<i>E. labuanum</i> ,
<i>B. andersonii</i> ,	<i>C. williamsonii</i> ,	<i>Epipogium roseum</i> ,
<i>B. arcuatilabium</i> ,	<i>Coelogyne fimbriata</i> ,	<i>Eria acervata</i> ,
<i>B. bisetoides</i> ,	<i>C. lockii</i> ,	<i>E. amica</i> ,
<i>B. concinnum</i> ,	<i>C. malipoënsis</i> ,	<i>E. apertiflora</i> ,
<i>B. emarginatum</i> ,	<i>C. rigida</i> ,	<i>E. biflora</i> ,
<i>B. fischeri</i> ,	<i>C. schultesii</i> ,	<i>E. boniana</i> ,
<i>B. guttulatam</i> ,	<i>Collabium assamicum</i> ,	<i>E. carinata</i> ,
<i>B. hirtum</i> ,	<i>C. chinense</i> ,	<i>E. corneri</i> ,
<i>B. hymenanthum</i> ,	<i>Corymborkis veratrifolia</i> ,	<i>E. coronaria</i> ,
<i>B. laxiflorum</i> ,	<i>Cryptochilus lutea</i> ,	<i>E. crassifolia</i> ,
<i>B. longiflorum</i> ,	<i>Cryptostylis arachnites</i> ,	<i>E. dacrydium</i> ,
<i>B. macraei</i> ,	<i>Cymbidium aloifolium</i> ,	<i>E. foetida</i> ,
<i>B. macranthum</i> ,	<i>C. cyperifolium</i> ,	<i>E. globulifera</i> ,
<i>B. modestum</i> ,	<i>C. dayanum</i> ,	<i>E. pannea</i> ,
<i>B. odoratissimum</i> ,	<i>C. ensifolium</i> ,	<i>E. pusilla</i> ,
<i>B. parviflorum</i> ,	<i>C. erythraeum</i> ,	<i>E. siamensis</i> ,
<i>B. picturatum</i> ,	<i>C. floribundum</i> ,	<i>E. sutepensis</i> ,
<i>B. purpureifolium</i> ,	<i>C. lancifolium</i> ,	<i>E. thao</i> ,
<i>B. reptans</i> ,	<i>C. sinense</i> ,	<i>E. truncata</i> ,
<i>B. retusiusculum</i> ,	<i>C. suavissimum</i> ,	<i>Erythrodes blumei</i> ,
<i>B. stenobulbon</i> ,	<i>Dendrobium acinaciforme</i> ,	<i>Erythrorchis ochobiensis</i> ,
<i>B. striatum</i> ,	<i>D. aduncum</i> ,	<i>Eulophia graminea</i> ,
<i>B. umbellatum</i> ,	<i>D. anosmum</i> ,	<i>Flickingeria fimbriata</i> ,
<i>B. xylophyllum</i> ,	<i>D. cariniferum</i> ,	<i>F. ritaeana</i> ,
<i>Calanthe alleizettei</i> ,	<i>D. chittimae</i> ,	<i>Galeola nudifolia</i> ,
<i>C. angusta</i> ,	<i>D. chrysanthum</i> ,	<i>Gastrochilus acutifolius</i> ,
<i>C. argenteo-striata</i> ,	<i>D. dentatum</i> ,	<i>G. minutiflorus</i> ,
<i>C. clavata</i> ,	<i>D. devonianum</i> ,	<i>G. pseudodistichus</i> ,

- Geodorum attenuatum*,
G. densiflorum,
Goodyera foliosa,
G. fumata,
G. hispida,
G. procera,
G. schlechtendaliana,
G. viridiflora,
Habenaria acuifera,
H. ciliolaris,
H. dentata,
H. linguella,
H. malintana,
H. malleifera,
H. petelotii,
H. praetermissa,
H. rhodocheila,
H. thailandica,
H. tonkinensis,
Hemipilia calophylla,
Holcoglossum wangii,
Hygrochilus parishii,
Liparis acuminata,
L. averyanoviana,
L. balansae,
L. bootanensis,
L. cespitosa,
L. chapaënsis,
L. conopea,
L. cordifolia,
L. delicatula,
L. distans,
L. elliptica,
L. emarginata,
L. latilabris,
L. luteola,
L. mannii,
L. nervosa,
L. nigra,
L. paradoxa,
L. petelotii,
L. petiolata,
L. plantaginea,
L. pterostyloides,
L. stricklandiana,
L. viridiflora,
Ludisia discolor,
Luisia appressifolia,
L. morsei,
L. psyche,
L. zollingeri,
Malaxis acuminata,
Malleola seidenfadenii,
Micropera poilanei,
Mischobulbon cordifolium,
M. macranthum,
Monomeria barbata,
Nephelaphyllum tenuiflorum,
Nervilia aragoana,
N. fordii,
N. punctata,
Neuwiedia annamensis,
N. griffithii,
Oberonia cavaleriei,
O. ensiformis,
O. evrardii,
O. falconeri,
O. quadridentata,
Ornithochilus difformis,
Otochilus porrectus,
O. pseudoporrectus,
Pachystoma pubescens,
Panisea yunnanensis,
Paphiopedilum barbigerum,
P. concolor,
P. dianthum,
P. emesonii,
P. gratixianum,
P. hangianum,
P. helenae,
P. henryanum,
P. hirsutissimum,
P. malipoënsis,
P. micranthum,
P. purpuratum,
P. vietnamense,
Pelatantheria ctenoglossum,
P. insectifera,
P. rivesii,
Peristylus prainii,
Phaius flavus,
P. indochinensis,
P. longicruris,
P. mishmensis,
P. tankervilleae,
Phalaenopsis gibbosa,
P. mannii,
P. parishii,
Pholidota articulata,
P. chinensis,
P. leveilleana,
P. missionariorum,
P. recurva,
P. roseans,
P. rubra,
P. yunnanensis,
Platanthera angustata,
Pleione praecox,
Pleione grandiflora,
Podochilus cultratus,
P. microphyllus,
Pomatocalpa spicata,
Porpax lanii,
Pteroceras simondianum,
Renanthera citrina,
R. coccinea,
R. imschootiana,
R. vietnamensis,
Rhomboda petelotii,
Rhynchostylis retusa,
Robiquetia spathulata,
R. succisa,
Schoenorchis gemmata,
Spiranthes sinensis,
Sunipia scariosa,
Tainia hongkongensis,
T. latifolia,
T. ruybarrettoii,
T. viridifusca,
Thecostele alata,
Thelasis khasiana,
T. pygmaea,
Thrixspermum calceolus,
T. carnosum,
T. centipeda,
T. formosanum,
Thunia alba,
Trichotomia dasyphylla,
T. pulvinata,
T. velutina,
Tropidia angulosa,
T. curculigoides,
Vanda concolor,
V. fuscoviridis,
Vandopsis gigantea,
Vanilla albida,
Yoania prainii,
Zeuxine strateumatica.

At elevations at or above 1500 m within this floristic province the flora contains considerable numbers of Holarctic subtropical and temperate floristic elements. This influence is most clearly pronounced in wet habitats on higher silicate mountains. The relative proportion of such elements here is similar to that found in the highland plant communities of the Sikang–Yunnan Province. The most common taxa of this group are mentioned below:

<i>Aceraceae</i> (<i>Acer</i>),	<i>Gentianaceae</i> (<i>Gentiana</i> , <i>Swertia</i>),
<i>Anacardiaceae</i> (<i>Pistacia</i>),	<i>Geraniaceae</i> (<i>Geranium</i>),
<i>Apiaceae</i> (<i>Cryptotaenia</i> , <i>Heracleum</i> , <i>Pternopetalum</i> , <i>Sanicula</i> , <i>Torilis</i>),	<i>Hamamelidaceae</i> (<i>Liquidambar</i>),
<i>Araliaceae</i> (<i>Eleutherococcus</i> , <i>Hedera</i>),	<i>Hippocastanaceae</i> (<i>Aesculus</i>),
<i>Aristolochiaceae</i> (<i>Asarum</i>),	<i>Hydrangeaceae</i> (<i>Hydrangea</i>),
<i>Asteraceae</i> (<i>Aster</i> s. l., <i>Cirsium</i> , <i>Crepis</i> , <i>Erigeron</i> , <i>Gnaphalium</i> , <i>Leontopodium</i> , <i>Senecio</i> , <i>Solidago</i> , <i>Sonchus</i> , <i>Taraxacum</i>),	<i>Iridaceae</i> (<i>Iris</i>),
<i>Berberidaceae</i> (<i>Berberis</i> , <i>Mahonia</i>),	<i>Juglandaceae</i> (<i>Platycarya</i>),
<i>Betulaceae</i> (<i>Alnus</i> , <i>Betula</i> , <i>Carpinus</i>),	<i>Juncaceae</i> (<i>Juncus</i>),
<i>Brassicaceae</i> (<i>Capsella</i> , <i>Rorippa</i>),	<i>Lamiaceae</i> (<i>Leonurus</i> , <i>Prunella</i> , <i>Stachys</i>),
<i>Caprifoliaceae</i> (<i>Lonicera</i>),	<i>Liliaceae</i> (<i>Lilium</i>),
<i>Caryophyllaceae</i> (<i>Stellaria</i>),	<i>Moraceae</i> (<i>Morus</i>),
<i>Celastraceae</i> (<i>Celastrus</i> , <i>Euonymus</i>),	<i>Plantaginaceae</i> (<i>Plantago</i>),
<i>Chenopodiaceae</i> (<i>Chenopodium</i>),	<i>Podophyllaceae</i> (<i>Podophyllum</i>),
<i>Convallariaceae</i> (<i>Disporum</i> , <i>Polygonatum</i>),	<i>Primulaceae</i> (<i>Primula</i> , <i>Lysimachia</i>),
<i>Cornaceae</i> (<i>Cornus</i>),	<i>Ranunculaceae</i> (<i>Aconitum</i> , <i>Anemone</i> , <i>Clematis</i> , <i>Ranunculus</i> , <i>Thalictrum</i>),
<i>Crassulaceae</i> (<i>Sedum</i>),	<i>Rosaceae</i> (<i>Agrimonia</i> , <i>Fragaria</i> , <i>Geum</i> , <i>Potentilla</i> , <i>Rosa</i> , <i>Sorbus</i> , <i>Spiraea</i> , <i>Photinia</i>),
<i>Dipsacaceae</i> (<i>Dipsacus</i>),	<i>Rubiaceae</i> (<i>Galium</i> , <i>Rubia</i>),
<i>Elaeagnaceae</i> (<i>Elaeagnus</i>),	<i>Saxifragaceae</i> (<i>Saxifraga</i>),
<i>Ericaceae</i> (<i>Enkianthus</i> , <i>Rhododendron</i> , <i>Vaccinium</i>),	<i>Smilacaceae</i> (<i>Smilax</i>),
<i>Fumariaceae</i> (<i>Corydalis</i>),	<i>Ulmaceae</i> (<i>Ulmus</i>),
<i>Fabaceae</i> (<i>Astragalus</i>),	<i>Valerianaceae</i> (<i>Patrinia</i> , <i>Valeriana</i>),
<i>Fagaceae</i> (<i>Quercus</i>),	<i>Violaceae</i> (<i>Viola</i>).

The Pteridophyte flora within this area is very rich with numerous species of *Cheilanthes*, *Diplasium* and *Polystichum* as well as terrestrial and lithophytic orchids such as *Bletilla ochracea*, *Goodyera schlechtendaliana*, *Hemipilia calophylla* and *Platanthera angustata*. The species composition of the canopy and understory vegetation resembles the more tropical characteristics of the flora of the South-Chinese floristic province, especially at low elevations. Numerous species of more tropical families such as *Acanthaceae*, *Balanophoraceae*, *Begoniaceae*, *Clusiaceae*, *Cycadaceae*, *Gesneriaceae*, *Melastomataceae*, *Meliaceae*, *Moraceae*, *Piperaceae*, *Proteaceae*, *Sapindaceae*, *Urticaceae*, many woody representatives of *Euphorbiaceae*, *Fabaceae*, *Rubiaceae*, different kinds of palms and giant herbs from *Zingiberaceae*, *Maranthaceae* and *Musaceae* are very common here. Not especially tall but quite typical mangrove thickets developing along coastal areas of Bac Bo (Tonkin) Gulf (Averyanov *et al.* 1988) also underline the tropical character of the flora of the South-Chinese Province. This floristic province is commonly treated as a subdivision of the Paleotropic Kingdom (Takhtajan 1978, 1986; Wu Zhengyi & Wu Sugong 1998).

7.3. North Indochinese Province

The long, deep valley of the Song Hong (Red River) geographically separates the South-Chinese Province from the lowland, hilly and montane regions of northern Vietnam. These

northern montane areas for the most part occur within the main part of the North Indochinese floristic province (Fig. 3). In Vietnam this floristic region includes the south-east tropical regions of Lai Chau, south-western parts of Lao Cai, Yen Bai, Vinh Phuc, as well as Son La, Phu Tho, Ha Tay, Hoa Binh, Ha Nam, Ninh Binh, Nam Dinh, Thanh Hoa, Nghe Anh, Ha Tinh and Quang Binh administrative provinces. The southern border of the North Indochinese floristic province in Laos and Vietnam coincides with the southern boundary of a large system of ancient eroded limestone massifs that extends in the northwest to southeast direction and represents an important biogeographic boundary in the area. In Vietnam it coincides approximately with the southern boundary of Quang Binh administrative province. The western boundary of the North Indochinese Province outlines montane areas of northern Laos, embracing the administrative provinces of Louang Namtha, Bokeo, Oudomsai, Louang Prabang, Houa Phan, Xieng Khouang, Vientiane, Bolikhamsai and Khammouane. On the west this area adjoins the Thai floristic province of Takhtajan (1978, 1986).

The North Indochinese Province covers mostly mountainous areas. These mountains are essentially the southern extension of the Himalayan highlands and are of complicated geological structure and origin. Ancient tectonic folding of Paleozoic and early Mesozoic ages (especially during the so-called Indosinian Folding) were consolidated in this region by extensive Mesozoic magmatic intrusions. Subsequent uplifts and erosion of these areas were main factors influencing the modern landscape formations in this area. In this region numerous mountain ridges, oriented mainly northwest-southeast, are composed mainly of granite, gneiss, rhyolites, dacites and other related silicate rocks, but also of various kinds of metamorphosed shale, schist and sandstones (Schzeglova 1957; Fridland 1961; Dovzikov *et al.* 1965a; Rundel 1999). The largest mountain systems in this area are Sam Sao, Houa Phan, the Xiang Khoang and Nakay plateaux that are actually northern extensions of the Truong Son Ridge. All these mountain systems lie mainly in Laos and only their eastern margins extend into Vietnam. The highest mountain formations of the area are situated along Laos–Vietnam border. These peaks, Xai Lai Leng (2711 m), Phu Hoat (2452 m), Rao Co (2235 m), Muong Tip (2040 m a.s.l.) and many others are mainly composed of Triassic granite (Dovzikov *et al.* 1965b). Deep river valleys separate numerous ridges and montane plateaux within the North Indochinese floristic province.

A chain of continuous limestone plateaux, Sin Ho (Ta Phin), Son La and Moc Chau with elevations up to 1500–1700 m a.s.l., is developed along the Song Da (Black) River extending from the Chinese border to the coast within this floristic province. Other large limestone areas transect the northern and central sections of the Truong Son Range in Nghe An (Con Cuong region) and Quang Binh (Ke Bang area) administrative provinces. In many places these plateaux are composed of solid, highly metamorphosed marble-like Paleozoic and Mesozoic limestone and are dissected by deep river valleys or deeply eroded by karst. Very often these ancient limestone deposits have weathered into spectacular karstic topography with numerous narrow rocky ridges and flat-topped mountains with nearly vertical cliffs faces. Very deep karstic erosion of ancient limestone deposits is very typical of lowland coastal plains in this floristic province, and widely scattered, isolated mesae-like remnants often form low hills. The exposed rocky limestone landscape provides unique habitats of plant communities with numerous local endemics.

Four different climate types are found in the North Indochinese floristic province (Nguyen Khanh Van *et al.* 2000). Monsoon tropical climate with cold winter and summer rains is typical of the largest part of the northern portion (Fig. 1). These climatic conditions are similar to those found in the largest part of the Vietnamese portion of the South Chinese Province.

A similar climate type is recognized in the central and southern part of the North Indochinese floristic province adjoining the border with Laos (Fig. 1). Annual temperatures here are similar to those previously mentioned, however maximum rainfall in this area is shifted from summer towards autumn. This climatic regime is classified as monsoon tropical climate with cold winter and summer-autumn rains (Nguyen Khanh Van *et al.* 2000).

In the southeastern coastal regions of the North Indochinese Province mean winter temperatures are distinctly higher than in both previous climatic zones and vary between 18–20° C. Absolute minima of between 5–10° C have been recorded from several recording stations. Normal summer temperatures here are 25–30° C. This climate type is characterized as monsoon tropical climate with warm winter and summer-autumn-winter rains (Nguyen Khanh Van *et al.* 2000).

A very humid, monsoon tropical climate associated with mountains is observed in highland areas of the North Indochinese Province on numerous high mountain peaks (Fig. 1). Climate conditions under the influence of moisture-laden cloud cover are similar to those described for the highland areas of the Sikang–Yunnan Province.

Mean annual rainfall throughout the North Indochinese Province varies from 1000 to 3000 mm (Fig. 2). The rainy period here is usually from May to November with a distinct dry season lasting throughout the winter and early spring. In mountain highlands the annual precipitation may be much higher. Due to abundant and frequent drizzly rains and mists, plant communities here often experience no dry period.

Tropical evergreen broad-leaved forests are typical of montane areas of the North Indochinese floristic province. Overall, the flora of this region shows obvious affinity to floras of the southern part of the Sikang–Yunnan floristic province. Numerous representatives of *Dipterocarpaceae* (*Hopea*), *Fabaceae* (*Ormosia*), *Fagaceae* (*Castanopsis*), *Lauraceae* (*Phoebe*), *Myrtaceae* (*Syzygium*), *Rosaceae*, *Sapotaceae* (*Madhuca*), *Ulmaceae* (*Gironniera*) as well as various palms are reported as canopy codominants in these forests (Rundel 1999). Emergent trees in lowland forests at elevations below 700 m a.s.l. in this area reach 30–50 m in height and these forest have a more continuous upper canopy at approximately 23–30 m. Numerous epiphytes and large woody lianas are very typical of this forest community. Thermophilous tropical trees such as *Hopea mollissima* (*Dipterocarpaceae*), *Ormosia balansae*, *O. merrilliana* (*Fabaceae*) and *Phoebe angustifolia* (*Lauraceae*) are important dominants of the upper forest stratum having clear tropical affinities in the lowland montane forests of the North Indochinese floristic province.

In the higher mountain areas of the North Indochinese Province zonation of the vegetation is clearly evident. Humid montane forests at 1000–2000 m in this area support rich primary communities dominated by gymnosperm species such as *Amentotaxus argotaenia*, *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Fokienia hodginsii*, *Keteleeria evelyniana*, *Nageia fleuryi*, *Nageia wallichiana*, *Podocarpus neriifolius* and *P. pilgeri*. More rare components of these communities are *Calocedrus macrolepis*, *Cunninghamia konishii* and *Taxus chinensis* (Nguyen Tien Hiep 1998; Phan Ke Loc & Nguyen Tien Hiep 1999; Nguyen Tien Hiep *et al.* 1999).

There are few doubts that highland plant communities of the North Indochinese Province at elevations above 2000 m a.s.l. include numerous subtropical and temperate holarctic elements. However sufficient and appropriate plant collections and scientific data from the high mountains of this area are still not available.

Unique types of broad-leaved evergreen and semi-deciduous forests are developed in the North Indochinese floristic province on rocky highly eroded remnants of solid limestone ridges. Due to karstic drainage, forest conditions here are drier than in plant communities on silicate rock substrates. In general, the species composition of limestone forests within the North Indochinese Province at lower elevations resembles that of the South Chinese floristic province. Evergreen broad-leaved tropical forests are typical of the limestone lowlands. Dominants within the first forest stratum are often taxa of such tropical families as *Anacardiaceae*, *Annonaceae*, *Clusiaceae*, *Combretaceae*, *Dipterocarpaceae*, *Ebenaceae*, *Euphorbiaceae*, *Juglandaceae*, *Moraceae*, *Rosaceae*, *Rubiaceae*, *Rutaceae*, *Sapindaceae*, *Sapotaceae* and *Sterculiaceae* as reported for lowland limestone areas within Cuc Phuong national park (Nguyen Nghia Thin 1994, 1997a). A single rare cycad, *Cycas miquelii*, occurs at low limestone elevations in this area.

At increasing elevations to (400) 700–1200 m a.s.l., broad-leaved forests in the North Indochinese floristic province often give way to semi-deciduous and mixed forests where

important subdominants of the canopy stratum are gymnosperm trees such as *Fokienia hodginsii*, *Nageia fleurii*, *Podocarpus neriifolius* and *P. pilgeri*. In the Ke Bang area the usual dominants within mixed forest on the tops of limestone ridges are *Dacrycarpus imbricatus* and *Dacrydium elatum* (Nguyen Tien Hiep *et al.* 1999). A common dominant tree on rocky limestone mountains of the South Chinese floristic province, *Pinus kwangtungensis*, is rarely encountered here (Phan Ke Loc 1984; Nguyen Tien Hiep 1998). Epiphytic and lithophytic bryophytes, ferns and orchids reach their maximum abundance and diversity in these forests.

The flora of the North Indochinese Province is still far from well-known and no acceptable inventories of these areas exist. Information is almost absent for the areas in Laos. Without doubt the flora is very rich and diverse, and still harbours a great number of exciting endemic novelties. Mountain forests that at present also spread to the highlands of the Central Annamese Province represent obvious remnants of a relic, more primitive and tropically allied flora such as occupied wide tropical and subtropical areas of Europe, Asia and North America during the early Tertiary 40–70 million years ago (Kubitzki & Krutzsch 1998). Due to progressive climate cooling and increasing aridity the European portion of this flora with its corresponding climatic zone disappeared nearly completely, with exception of the small relic depauperate representatives in Portugal, the Colchis and a few other orographically suitable regions. The largest segments of humid tropical Tertiary flora were shifted to East Asia. One of the richest and most extensive remnants of this ancient relictual flora may be now observed in highland areas of the North Indochinese and Central Annamese Provinces. The primary mountain forests of this region include a surprisingly large proportion of archaic genera represented as fossils of Upper Cretaceous and Lower Tertiary age recorded from Europe, East Asia and North America (Kubitzki & Krutzsch 1998; Averyanov & Nguyen Tien Hiep 2002). Recent plant communities of this area can act as real models for vegetation and climate reconstructions of the tertiary floras of the Holarctic (Martinetto 1998). On the other hand this area may be the birthplace and cradle of the Holarctic and Paleotropical flora (Wu Zhengyi & Wu Sugong 1998).

Sensational findings of a number of new species of mammals and other large, strictly endemic animals were also recently made in the Vu Quang nature reserve (Ha Tinh Province) situated in the southern part of the North Indochinese Province (Linden 1994). Within the flora there are a few endemic genera, including *Diphyllarium*, *Notodontia*, *Petelotiella* and *Vietorchis* (Takhtajan 1986; Averyanov & Averyanova 2003). About 28.5% of all Vietnamese plant endemics occur in the North Indochinese Province and 8.6% of endemic Vietnamese species are local endemics of this province (Fig. 4). Endemic species of selected families are listed below:

- | | |
|--|---|
| <i>Cycadaceae</i> (<i>Cycas chevalierii</i>), | <i>Cucurbitaceae</i> (<i>Trichosanthes baviensis</i>), |
| <i>Anacardiaceae</i> (<i>Buchanania atlopeuensis</i>), | <i>Dipterocarpaceae</i> (<i>Parashorea dussaudii</i> , |
| <i>Annonaceae</i> (<i>Alphonsea sonlaënsis</i> , | <i>Vatica subglabra</i>), |
| <i>A. squamosa</i> , <i>Goniothalamus</i> | <i>Euphorbiaceae</i> (<i>Actephila subsessilis</i> , |
| <i>macrocalyx</i> , <i>Orophea multiflora</i> , | <i>Alchornea chuathayensis</i> , <i>Antidesma</i> |
| <i>O. tonkinensis</i> , <i>Pseuduvaria</i> | <i>annamense</i> , <i>A. tonkinense</i> , <i>Baccaurea</i> |
| <i>indochinensis</i>), | <i>annamensis</i> , <i>Baliospermum balansae</i> , |
| <i>Araceae</i> (<i>Alocasia tonkinensis</i> , | <i>Breynia fleuryi</i> , <i>Bridelia chinensis</i> , |
| <i>Amorphophallus ochroleucus</i> , | <i>Cleidion bracteosum</i> , <i>Cleistanthus</i> |
| <i>A. verticillatus</i> , <i>Arisaema petelotii</i> , | <i>indochinensis</i> , <i>Croton latsonensis</i> , |
| <i>Homalomena tonkinensis</i> , <i>Raphidophora</i> | <i>Excoecaria aporosifolia</i> , <i>Glochidion</i> |
| <i>crassicaulis</i> , <i>Rh. laichauensis</i> , | <i>balansae</i> , <i>G. triloculare</i> , <i>Mallotus</i> |
| <i>Rh. tonkinensis</i> , <i>Steudnera henryana</i>), | <i>chuyenii</i> , <i>M. metcalfeanus</i> , <i>Phyllanthus</i> |
| <i>Araliaceae</i> (<i>Macropanax baviensis</i> , | <i>pacoensis</i> , <i>Ph. rubicundus</i> , |
| <i>Schefflera choganhensis</i> , <i>Sch. nitidifolia</i> , | <i>Ph. songboiensis</i> , <i>Sauropus kitanovii</i> , |
| <i>Sch. pacoensis</i> , <i>Sch. tonkinensis</i>), | <i>S. maichauensis</i> , <i>S. spatulaefolius</i> , |
| <i>Bignoniaceae</i> (<i>Fernandoa bracteata</i> , | <i>S. thoi</i> , <i>Trigonostemon bonianus</i>), |
| <i>F. brilletii</i> , <i>Radermachera boniana</i>), | |

Fabaceae (*Bauhinia oxysepala*, *B. rubro-villosa*, *B. subumbellata*, *Campylotropis bonii*, *Diphyllarium mekongense*, *Gleditsia pachycarpa*, *Ormosia elliptica*, *O. tonkinensis*, *Pueraria longicarpa*, *Shuteria annamica*, *Spatholobus balansae*, *Uraria balansae*, *U. pierrei*),
Flacourtiaceae (*Hydnocarpus annamensis*),
Juglandaceae (*Carya poilanei*),
Loganiaceae (*Mitreola reticulata*),
Lowiaceae (*Orchidantha laotica*),
Moraceae (*Ficus quichauensis*),
Myrsinaceae (*Ardisia baviensis*,
A. ramondiaeformis, *A. verbascifolia*,
A. vietnamensis, *Embelia bonii*, *Maesa macrosepala*),

Primulaceae (*Lysimachia baviensis*,
L. interjacens),
Proteaceae (*Helicia grandifolia*),
Sabiaceae (*Meliosma coriacea*, *M. longipes*,
M. thorelii),
Sapotaceae (*Eberhardtia aurata*,
Sinosideroxylon bonii, *Xantolis boniana*),
Scrophulariaceae (*Lindernia pterogona*,
L. tonkinensis),
Symplocaceae (*Symplocos singuliflora*),
Theaceae (*Adinandra bockiana*, *Anneslea paradoxa*, *Camellia flava*, *C. gilbertii*,
C. longicaudata, *C. petelotii*,
C. pleurocarpa, *C. pubicostata*,
C. tonkinensis, *Pyrenaria jonquieriana*),
Thymelaeaceae (*Gyrinops vidalii*).

About 202 orchid species from 77 genera are reported from the North Indochinese Province. 12 species and one monotypic genus *Vietorchis* (Averyanov & Averyanova 2003) are local endemics of this area (Table 6).

Table 6. Orchid species reported from the North Indochinese floristic province (local endemics of this area in bold)

<i>Acampe rigida</i> ,	<i>C. siamensis</i> ,	<i>D. fimbriatum</i> ,
<i>Aerides odorata</i> ,	<i>C. subulata</i> ,	<i>D. hercoglossum</i> ,
<i>A. rosea</i> ,	<i>Cheirostylis chinensis</i> ,	<i>D. lindleyi</i> ,
<i>Anoectochilus lanceolatus</i> ,	<i>C. yunnanensis</i> ,	<i>D. lomatochilum</i> ,
<i>Apostasia wallichii</i> ,	<i>Chiloschista trudelii</i> ,	<i>D. nobile</i> ,
<i>Appendicula cornuta</i> ,	<i>Cleisostoma aspersum</i> ,	<i>D. parishii</i> ,
<i>A. hexandra</i> ,	<i>C. paniculatum</i> ,	<i>D. pendulum</i> ,
<i>Arundina graminifolia</i> ,	<i>C. rostratum</i> ,	<i>D. podagraria</i> ,
<i>Biermannia calcarata</i> ,	<i>C. striatum</i> ,	<i>D. salaccense</i> ,
<i>Bulbophyllum andersonii</i> ,	<i>C. williamsonii</i> ,	<i>D. terminale</i> ,
<i>B. concinnum</i> ,	<i>Coelogyne fimbriata</i> ,	<i>D. thyrsiflorum</i> ,
<i>B. delitescens</i> ,	<i>Collabium chinense</i> ,	<i>D. tortile</i> ,
<i>B. flabellovenensis</i> ,	<i>Corymborkis veratrifolia</i> ,	<i>D. truncatum</i> ,
<i>B. hirundinis</i> ,	<i>Cymbidium aloifolium</i> ,	<i>D. virgineum</i> ,
<i>B. seidenfadenii</i> ,	<i>C. ensifolium</i> ,	<i>D. wardianum</i> ,
<i>B. spadiciflorum</i> ,	<i>C. finlaysonianum</i> ,	<i>Didymoplexiopsis</i>
<i>B. stenobulbon</i> ,	<i>C. lancifolium</i> ,	<i>khiriwongensis</i> ,
<i>B. taeniophyllum</i> ,	<i>C. sinense</i> ,	<i>Didymoplexis vietnamica</i> ,
<i>B. violaceolabellum</i> ,	<i>Cyrtosia javanica</i> ,	<i>Epigeneium labuanum</i> ,
<i>B. xylophyllum</i> ,	<i>Dendrobium acerosum</i> ,	<i>Epipogium roseum</i> ,
<i>Calanthe alismifolia</i> ,	<i>D. acinaciforme</i> ,	<i>Eria boniana</i> ,
<i>C. angusta</i> ,	<i>D. anosmum</i> ,	<i>E. corneri</i> ,
<i>C. argenteo-striata</i> ,	<i>D. chryseum</i> ,	<i>E. coronaria</i> ,
<i>C. herbacea</i> ,	<i>D. chrysotoxum</i> ,	<i>E. floribunda</i> ,
<i>C. triplicata</i> ,	<i>D. dentatum</i> ,	<i>E. gagnepainii</i> ,
<i>Callostylis rigida</i> ,	<i>D. ellipsophyllum</i> ,	<i>E. globulifera</i> ,
<i>Cephalanthera exigua</i> ,	<i>D. faulhaberianum</i> ,	<i>E. lanigera</i> ,
<i>Ceratostylis himalaica</i> ,	<i>D. filicaule</i> ,	<i>E. paniculata</i> ,

<i>E. pannea</i> ,	<i>L. mannii</i> ,	<i>Pholidota articulata</i> ,
<i>E. porteri</i> ,	<i>L. nervosa</i> ,	<i>P. chinensis</i> ,
<i>E. siamensis</i> ,	<i>L. nigra</i> ,	<i>P. convallariae</i> ,
<i>E. spirodela</i> ,	<i>L. petelotii</i> ,	<i>P. guibertiae</i> ,
<i>E. sutepensis</i> ,	<i>L. stricklandiana</i> ,	<i>P. rubra</i> ,
<i>E. thao</i> ,	<i>Ludisia discolor</i> ,	<i>P. yunnanensis</i> ,
<i>Erythrodes blumei</i> ,	<i>Luisia antennifera</i> ,	<i>Phreatia densiflora</i> ,
<i>Erythrorchis ochobiensis</i> ,	<i>L. morsei</i> ,	<i>P. plantaginifolia</i> ,
<i>Eulophia flava</i> ,	<i>Malaxis acuminata</i> ,	<i>Pleione praecox</i> ,
<i>E. graminea</i> ,	<i>M. ophridis</i> ,	<i>Podochilus cultratus</i> ,
<i>Flickingeria fimbriata</i> ,	<i>Malleola seidenfadenii</i> ,	<i>P. microphyllus</i> ,
<i>F. fugax</i> ,	<i>Mischobulbon macranthum</i> ,	<i>Pteroceras simondianum</i> ,
<i>F. ritaeana</i> ,	<i>M. ovalifolium</i> ,	<i>Renanthera coccinea</i> ,
<i>Galeola nudifolia</i> ,	<i>Nephelaphyllum pulchrum</i> ,	<i>Rhynchostylis retusa</i> ,
<i>Gastrochilus acutifolius</i> ,	<i>N. tenuiflorum</i> ,	<i>Robiquetia spathulata</i> ,
<i>G. obliquus</i> ,	<i>Neuwiedia annamensis</i> ,	<i>R. succisa</i> ,
<i>Geodorum attenuatum</i> ,	<i>N. griffithii</i> ,	<i>Schoenorchis brevirachis</i> ,
<i>Goodyera foliosa</i> ,	<i>N. inae</i> ,	<i>S. gemmata</i> ,
<i>G. fumata</i> ,	<i>N. singaporeana</i> ,	<i>Spathoglottis eburnea</i> ,
<i>G. hispida</i> ,	<i>Oberonia acaulis</i> ,	<i>Spiranthes sinensis</i> ,
<i>G. procera</i> ,	<i>O. delacourii</i> ,	<i>Stereosandra javanica</i> ,
<i>Habenaria ciliolaris</i> ,	<i>O. ensiformis</i> ,	<i>Tainia viridifusca</i> ,
<i>H. dentata</i> ,	<i>O. kwangsiensis</i> ,	<i>Thelasis pygmaea</i> ,
<i>H. malintana</i> ,	<i>O. pachyphylla</i> ,	<i>Thrixspermum calceolus</i> ,
<i>H. rhodocheila</i> ,	<i>Ornithochilus difformis</i> ,	<i>T. carnosum</i> ,
<i>H. tonkinensis</i> ,	<i>Otochilus fuscus</i> ,	<i>T. centipeda</i> ,
<i>H. viridiflora</i> ,	<i>Pachystoma pubescens</i> ,	<i>T. fleuryi</i> ,
<i>Hetaeria rubens</i> ,	<i>Paphiopedilum concolor</i> ,	<i>Trichotosia pulvinata</i> ,
<i>Holcoglossum saprophyticum</i> ,	<i>P. dianthum</i> ,	<i>T. velutina</i> ,
<i>Kingidium deliciosum</i> ,	<i>P. hirsutissimum</i> ,	<i>Tropidia angulosa</i> ,
<i>Liparis anatina</i> ,	<i>P. malipoënsis</i> ,	<i>T. curculigoides</i> ,
<i>L. averyanoviana</i> ,	<i>Pelatantheria insectifera</i> ,	<i>Vanda concolor</i> ,
<i>L. balansae</i> ,	<i>Peristylus parishii</i> ,	<i>Vanilla annamica</i> ,
<i>L. brunneolobulata</i> ,	<i>P. tentaculatus</i> ,	<i>Vietorchis aurea</i> ,
<i>L. cespitosa</i> ,	<i>Phaius flavus</i> ,	<i>Vrydagzynea albida</i> ,
<i>L. chapaënsis</i> ,	<i>P. indochinensis</i> ,	<i>Zeuxine nervosa</i> ,
<i>L. cordifolia</i> ,	<i>P. mishmensis</i> ,	<i>Z. parvifolia</i> ,
<i>L. distans</i> ,	<i>P. tankervilleae</i> ,	<i>Z. strateumatica</i> ,
<i>L. elliptica</i> ,	<i>Phalaenopsis gibbosa</i> ,	<i>Z. vietnamica</i> .
<i>L. latilabris</i> ,	<i>P. lobbii</i> ,	

Undoubtedly the total number of orchids found in the North Indochinese Province will increase dramatically with further exploration of this very unexplored region. The estimated total number of orchids that occur in this floristic province may as high as 350–400 species.

7.4. Central Annamese Province

Geographically the montane areas of the central section of the Truong Son Range delimit the Central Annamese floristic province. Also included and associated with this range are a number of high plateaux such as Kontum and Playcu in Vietnam, and Boloven Plateau in Laos. Lowlands of the Mekong River basin as well as basins of the Kong, San, Srepok and Da Rang rivers bound the province area on the west and south. Along the western boundary this area adjoins the Thaiandian

floristic province of Takhtajan (1978, 1986). The northern extension of the Central Annamese Province includes the granite mountain massifs of the Truong Son Ridge interrupted in its narrowest part by a relatively lowland, rocky limestone area belonging to the North Indochinese Province. The coastline along the South China Sea forms the eastern margin of the province. A few small islands of continental origin and Hoang Sa atoll archipelago also belong to the Central Annamese floristic province (Fig. 3).

In Vietnam the Central Annamese floristic province includes the southern portion of Quang Binh administrative province, Quang Tri, Thua Thien Hue, Quang Nam, Quang Ngai, Kon Tum and Binh Dinh Provinces, as well as Da Nang city and northern districts of Gia Lai and Phu Yen Provinces. In Laos the eastern portions of Savannakhet, Saravan, Cham Pasak, and areas of Se Kong and Attapu administrative provinces belong to this floristic province. A montane northeastern portion of Ratanakiri administrative province of Cambodia should also be included in this floristic region.

The largest portion of the Central Annamese floristic province contains the mountainous areas associated with Truong Son Ridge. Geographically in a broad sense this ridge represents a long southern extension of the Himalayas. These areas lie on a basement of an ancient crystalline platform composed of Precambrian gneiss often covered with more or less highly metamorphosed continental and marine sediments such as clay or quartzite sandstones, slate or schist. During its long history this solid platform was not folded. The platform was dissected during great Paleozoic and Mesozoic orogenic movements into a number of large uplifted blocks forming separate plateaux at different elevations. The largest of these blocks in the area are the Atouat, Kontum, Playcu and Boloven plateaux with mean elevations of about 700–1000 m a.s.l. Numerous more or less large mountain massifs tower above the basement of these plateaux. Most of them are formed by various extensive granite intrusions of late Mesozoic age (Schzeglova 1957; Rundel 1999). Ngoc Linh, a large granite massif, is the largest mountain system in the area. It contains the highest peaks in southern Indochina, Ngoc Linh (2598 m) and Ngoc Gua (2576 m). Occasionally side branches of the main Truong Son Range spread in an eastern direction. Among them Bachma Ridge, with main peaks to 1200–1700 m a.s.l., extends towards the coast to the north of Da Nang. Ancient volcanic activity is evident throughout the Central Annamese Province as chains of ancient extinct volcanoes that have been subsequently destroyed by erosion (Schzeglova 1957; Rundel 1999). The area contained within the province represents a complex mosaic composed of late Paleozoic and early Mesozoic granite intrusives and volcanic effusives of different age appearing along geological faults. Scattered areas of ancient basement gneiss and granite outcrops are also present in the area especially on steep east-facing slopes of mountains facing the sea (Schzeglova 1957; Rundel 1999).

Five different climate types are observed in the Central Annamese floristic province (Nguyen Khanh Van *et al.* 2000).

A monsoon tropical climate with a cold winter and summer–autumn rains is typical of the extreme northwestern mountain districts of the Central Annamese Province (Fig. 1). These climatic conditions are very similar to climate patterns observed in the southern part of the North Indochinese floristic province. Mean winter temperatures here are around 17–18° C with recorded minimum (1) 4–8° C and summer is warm with mean temperatures about 27–29° C. Peak rainfall is commonly observed during August–November (Nguyen Khanh Van *et al.* 2000). Mean annual precipitation in this region is 2000–2500 mm (Fig. 2).

A monsoon tropical climate with a warm winter and summer–autumn–winter rains is observed on the eastern slopes of Truong Son Range and on coastal plains in the northeastern portion of the Central Annamese floristic province. Mean winter temperatures in this area are about 19–24° C with common summer temperatures around 27–30° C. Most rains fall in September–November (Nguyen Khanh Van *et al.* 2000) with mean annual precipitation about 2000–3000 mm. Annual rainfall amounts increase dramatically with increases in elevation

especially on the eastern slopes of the Truong Son Range and may reach more than 4000 mm (Fig. 2).

Temperature conditions very similar to those observed in the previously described area are typical of the southern part of the Central Annamese floristic province. In the coastal areas of the southeastern part of the province, rainfall occurs most often in September–November and sometimes December. This area is characterized as an area of monsoon tropical climate with warm winter and autumn–winter rains (Nguyen Khanh Van *et al.* 2000). Usual annual precipitation in this region is 1000–2000 mm (Fig. 2). In the continental southwestern part of the province, rainfall occurs during the summer months. The climate here is characterized as monsoon tropical with warm winter and summer rains (Nguyen Khanh Van *et al.* 2000). Annual rainfall here reaches 1500–3500 mm.

Wide highland mountain areas in the central portions of the Central Annamese floristic province have a very humid and cool climate characterized as monsoon tropical associated with mountains (Nguyen Khanh Van *et al.* 2000). Temperature conditions in mountain regions depend on elevation. At elevations below 1000 m a.s.l., winter and summer temperatures are rather uniform between 25–30° C. Night temperatures of the coldest winter months at above 1600 m a.s.l. may dip down to 0° C. Winter day temperatures at these elevations are usually 14–18° C. The rainy season in this area usually lasts from July to the end of October. The winter is relatively dry, but at elevations above 1400–1600 m, winter rains are not uncommon. At these elevations heavy clouds and drizzle are very common often increasing the annual rainfall to more than 4000 mm. In regions of the Central Annamese Province the highest annual rainfall in Vietnam is recorded. According to recent observations, the mean annual precipitation may reach as high as 6000–7000 mm, as recorded on Bach Ma Ridge near Hai Van Pass (Nguyen Khanh Van, pers. comm.).

Tropical closed evergreen broad-leaved and mixed montane forests are most typical of mountain areas of the Central Annamese floristic province. Thermophilous evergreen broad-leaved submontane forests are developed within the area in the warm and humid conditions of river valleys at elevation of 800–1500 m a.s.l. Winter temperatures here rarely fall lower than 18–20° C. These forests are generally composed of thermo- and hygrophilous typically tropical species. Within these forests canopy trees reach 30–40 m in height. The canopy trees belong to tropical families such as the *Anacardiaceae*, *Fabaceae*, *Euphorbiaceae*, *Meliaceae*, *Moraceae* and *Sterculiaceae*. Giant herbs such as bananas (*Musaceae*), aroids (*Araceae*), *Phrynium dispernum*, woody ferns with stems up to 15 m height and tall, large leaved palms, large woody lianas (*Artabotrys*, *Entada*, *Ipomoea*, *Spatholobus*, *Tetrastigma*), creeping herbaceous vines (*Epipremnum*, *Pothos*, *Raphidophora*, *Scindapsus*) and numerous epiphytes are important integral components of these forests. Submontane forests have one of the highest levels of biodiversity among the vegetation types of the area.

Humid, broad-leaved submontane forests are widely distributed on the more wet and warm east, northeast and southeast slopes of mountain systems. On drier slopes facing west broad-leaved submontane forests often give way to mixed and coniferous forests with *Pinus kesiya* as a main dominant.

Mixed and coniferous submontane forests are widely distributed within the Central Annamese floristic province at elevations of 800–1500 m a.s.l. *Pinus kesiya* is frequently encountered and often the sole canopy dominant in such forests. This tree commonly reaches 30–35 m high with trunks up to 1 m in diameter at breast height. Occasionally *Keteleeria evelyniana* and *Podocarpus neriifolius* also occur in these forests especially in local depressions of suitable microclimate. At lower elevations *Pinus merkusii* is an important dominant in coniferous lowland woodlands. In closed mixed forests on dry well drained soils at 700–1100 m a.s.l. *Dacrycarpus imbricatus* and *Dacrydium elatum* are frequent dominants of the forest. A number of dry-tolerant elements of broad-leaved forests occur in mixed and coniferous forest. Within this floristic province they often compose the second canopy stratum. The most common trees are representatives of *Ericaceae*, *Euphorbiaceae*, *Fagaceae*, *Lauraceae*, *Moraceae* and *Saurauiceae*. Sometimes in open,

monospecific pine forests, occasional individual broad-leaved trees play the role of "ecological islands" for epiphytes. Commonly on these trees numerous epiphytic orchids, ferns and parasitic shrubs such as *Viscum articulatum*, *Korthalsella opuntia*, *Dendrophthoe varians*, *Helixanthera* sp., *Macrosolen chinensis* and *Taxillus* sp. may be found. The shrub component is often rather low at 3–4 m high and includes taxa of *Phyllanthus*, *Melastoma*, *Lauraceae*, *Cycas pectinata* and several dwarf palms, such as *Phoenix siamensis*. Many dry-tolerant ferns, grasses, herbs and small vines are found in the undergrowth of light coniferous woodlands. Very common among them are *Lagenophora gracilis*, *Elephantopus scaber*, as well as species of *Carex*, *Curcuma*, *Elaphoglossum*, *Fimbristylis*, *Kaempferia*, *Pyrrosia*, *Scleria*, *Smilax*, *Zingiber* and many others.

Broad-leaved evergreen montane forests are the most widespread types of vegetation in the Central Annamese floristic province. They are mainly developed at elevations from 1400 to 2200 (2300) m a.s.l. Night winter temperatures in coldest night can sometimes fall to 0° C. As a result of these occasional low temperatures the forest does not contain the most typical tropical species. Tall woody ferns, large palms and giant herbs are absent from the flora here. Common canopy dominants belong to following families:

- | | |
|--|---|
| <i>Aceraceae</i> (<i>Acer flabellatum</i> , <i>Acer</i> sp.), | <i>Juglandaceae</i> (<i>Engelhardtia spicata</i>), |
| <i>Betulaceae</i> (<i>Betula alnoides</i>), | <i>Lauraceae</i> (<i>Cinnamomum cassia</i> , |
| <i>Clusiaceae</i> (<i>Garcinia</i> sp.), | <i>Cinnamomum</i> sp., <i>Cryptocarya</i> sp., |
| <i>Elaeocarpaceae</i> (<i>Elaeocarpus</i> sp.), | <i>Litsea</i> sp., <i>Neolitsea cambodiana</i> , |
| <i>Ericaceae</i> (<i>Rhododendron</i> sp.), | <i>Neolitsea</i> sp., <i>Phoebe lanceolata</i> , |
| <i>Fagaceae</i> (<i>Castanopsis</i> sp., <i>Quercus</i> | <i>Ph. paniculata</i>), |
| <i>langbianensis</i> , <i>Q. macrocalyx</i> , <i>Quercus</i> | <i>Magnoliaceae</i> (<i>Magnolia</i> sp., <i>Manglietia</i> sp., |
| sp., <i>Lithocarpus vidaliana</i> , <i>Lithocarpus</i> | <i>Michelia foveolata</i>), |
| sp.), | <i>Mastixiaceae</i> (<i>Diplopanax</i> sp.), |
| <i>Hamamelidaceae</i> (<i>Symingtonia populnea</i> , | <i>Myrtaceae</i> (<i>Syzygium</i> sp.), |
| <i>S. tonkinensis</i> , <i>Rhodoleia championii</i>), | <i>Rosaceae</i> (<i>Sorbus corymbifera</i> , <i>S. wattii</i>), |
| <i>Iteaceae</i> (<i>Itea chinensis</i>), | <i>Theaceae</i> (<i>Ternstroemia kwangtungensis</i>). |

Canopy trees may reach 20–30 m high. Occasionally at elevations above 1500 m in the montane forests of the area, *Pinus dalatensis* with stems more than 2 m in diameter at breast height reaches 30–40 m high. The age of these giant emergent trees may be more than 1000 years. Their canopies are the typical habitat of rare epiphytic orchids *Dendrobium christyanum*, *D. wattii*, *Bulbophyllum hymenantum* and *B. ngoclinensis*. Other large gymnosperm trees like *Fokienia hodginsii* also are occasionally common here.

The second and third strata of these forests include medium height trees to about 5–10 m high. Most common in the second level are taxa of the *Theaceae*, *Araliaceae*, *Lauraceae* and *Annonaceae*. The third level is composed of numerous small trees and shrubs to 3–4 m high. Most common among them are representatives of the following families and genera:

- | | |
|--|--|
| <i>Acanthaceae</i> (<i>Strobilanthes echinata</i>), | <i>Ebenaceae</i> (<i>Diospyros</i> sp.), |
| <i>Annonaceae</i> (<i>Enicosanthellum</i> | <i>Melastomataceae</i> (<i>Blastus</i> sp., <i>Melastoma</i> |
| <i>plagioneurum</i>), | sp.), |
| <i>Apocynaceae</i> (<i>Tabernaemontana</i> sp.), | <i>Meliaceae</i> (<i>Lansium domesticum</i>), |
| <i>Aquifoliaceae</i> (<i>Ilex micrococca</i>), | <i>Myrsinaceae</i> (<i>Ardisia</i> spp.), |
| <i>Araliaceae</i> (<i>Brassaiaopsis glomerulata</i> , | <i>Pittosporaceae</i> (<i>Pittosporum balansae</i>), |
| <i>Schefflera hypoleuca</i> , <i>S. metcalfiana</i>), | <i>Polygalaceae</i> (<i>Polygala saxicola</i>), |
| <i>Arecaceae</i> (<i>Calamus</i> spp.), | <i>Rubiaceae</i> (<i>Lasianthus</i> spp., <i>Psychotria</i> spp., |
| <i>Celastraceae</i> (<i>Euonymus javanicus</i> , | <i>Tarenna</i> spp., <i>Wendlandia</i> spp.), |
| <i>E. rubescens</i> , <i>Glyptopetalum annamense</i> , | <i>Thymelaeaceae</i> (<i>Wikstroemia</i> sp.). |
| <i>G. chaudocense</i> , <i>G. gracilipes</i>), | |

Woody ferns with stems up to 1.5–2 m high are also very common here. In wet, more open places, especially along streamside cliffs, climbing shrubs of *Rubus annamensis* and *R. alpestris* (*Rosaceae*) combined with *Strobilanthes echinata* and *Dichroa febrifuga* form dense impassible thickets. A great diversity of ferns is quite typical of the forests of the Ngoc Linh mountain system. There are also many epiphytes, lithophytes, creeping vines and terrestrial species. Occasionally, very large forms of ferns with fronds up to 3 m long occur, but usually their stems do not exceed 1–2 m tall. Epiphytic and terrestrial orchids are also common, but their diversity is lower than in warm submontane forests.

Besides numerous ferns the main codominants in the undershrub and herbaceous vegetation of mountain forests of the Central Annamese floristic province are species of the following families and genera:

<i>Acanthaceae</i> (<i>Dicliptera</i> , <i>Justicia</i> , <i>Nelsonia</i> , <i>Peristrophe</i> , <i>Phlogacanthus</i> , <i>Staurogyne</i> , <i>Strobilanthes</i>),	<i>Melastomataceae</i> (<i>Blastus</i> , <i>Medinilla</i> , <i>Phyllagathis</i> , <i>Sarcopyramis</i> , <i>Sonerila</i>),
<i>Araceae</i> (<i>Arisaema</i> , <i>Alocasia</i>),	<i>Orchidaceae</i> (<i>Anoectochilus</i> , <i>Calanthe</i> , <i>Cymbidium</i> , <i>Goodyera</i> , <i>Nephelaphyllum</i> , <i>Tainia</i>),
<i>Begoniaceae</i> (<i>Begonia</i>),	<i>Rubiaceae</i> (<i>Argostemma</i> , <i>Geophila</i> , <i>Hedyotis</i> , <i>Lasianthus</i> , <i>Ophiorrhiza</i>),
<i>Cyperaceae</i> (<i>Carex</i> , <i>Scleria</i>),	<i>Selaginellaceae</i> (<i>Selaginella</i>),
<i>Gesneriaceae</i> (<i>Chirita</i> , <i>Didymocarpus</i> , <i>Didissandra</i> , <i>Slackia</i>),	<i>Urticaceae</i> (<i>Elatostema</i> , <i>Pellionia</i> , <i>Pilea</i>).
<i>Hydrangeaceae</i> (<i>Dichroa febrifuga</i>),	

Highly specialized tropical parasites within the *Balanophoraceae*, including *Balanophora fungosa*, *B. indica*, *B. laxiflora* and *Rhopalocnemis phalloides* are often components of these mountain forests, especially in places of deep leaf litter and humus accumulation. Rare saprophytes *Didimoplexiopsis*, *Lecanorchis* (*Orchidaceae*) and *Petrosavia* (*Melanthiaceae*) are also found here in these conditions. At elevations higher than 2000 m a.s.l. an abundance of terrestrial and lithophytic bryophytes and lichens is observed. Vertical wet rocky cliffs are sometimes covered with a thick layer of *Sphagnum* mosses. Epiphytes and lithophytes are very common in montane forests of the province including numerous ferns, *Lycopodium* species, orchids, small pendent epiphytic shrubs, like *Piper* and *Aeschynanthus* as well as vines, such as *Medinilla alternifolia*, *Smilax* spp. etc.

In more or less disturbed mountain forests there are usually widely scattered trees, shrubs and lianas that belong to species more typically found in secondary woody vegetation. The following families and genera are common and widespread:

<i>Alangiaceae</i> (<i>Alangium kurzei</i>),	<i>Mallotus</i> sp., <i>Phyllanthus emblica</i> ,
<i>Anacardiaceae</i> (<i>Rhus chinensis</i> ,	<i>Phyllanthus</i> sp.),
<i>Toxicodendron rhesoides</i> ,	<i>Hypericaceae</i> (<i>Hypericum uralum</i>),
<i>T. succedanea</i>),	<i>Moraceae</i> (<i>Broussonetia papyrifera</i> , <i>Ficus</i> sp.),
<i>Araliaceae</i> (<i>Aralia armata</i>),	<i>Myricaceae</i> (<i>Myrica esculenta</i>),
<i>Buddlejaceae</i> (<i>Buddleja paniculata</i>),	<i>Myrsinaceae</i> (<i>Embelia ribes</i> , <i>Maesa</i> sp.),
<i>Chloranthaceae</i> (<i>Hedyosmum orientale</i>),	<i>Oleaceae</i> (<i>Ligustrum chinensis</i>),
<i>Cornaceae</i> (<i>Cornus controversa</i>),	<i>Rosaceae</i> (<i>Rubus corchorifolius</i> ,
<i>Elaeocarpaceae</i> (<i>Elaeocarpus lancifolius</i>),	<i>R. obcordatus</i> , <i>R. niveus</i> , <i>R. asper</i>),
<i>Ericaceae</i> (<i>Lyonia ovalifolia</i>),	<i>Rubiaceae</i> (<i>Hedyotis</i> sp., <i>Ixora</i> sp.,
<i>Euphorbiaceae</i> (<i>Antidesma</i> sp., <i>Aporosa</i> sp.,	<i>Mussaenda</i> sp., <i>Paederia microcephala</i> ,
<i>Bischofia javanica</i> , <i>Breynia</i> sp.,	<i>P. scandens</i> , <i>Psychotria</i> sp., <i>Tarenna</i> sp.,
<i>Claoxyton indicum</i> , <i>Croton</i> sp.,	<i>Uncaria scandens</i> , <i>Wendlandia</i> sp.),
<i>Glochidion</i> sp., <i>Macaranga denticulata</i> ,	<i>Styracaceae</i> (<i>Alniphyllum fortunei</i>).
<i>Macaranga</i> sp., <i>Mallotus paniculatus</i> ,	

In damp or wet places large *Pandanus* sp. and species of giant tufted grasses, mainly *Thysanolaena maxima* and *Sorghum* sp. up to 4–5 m high, often occur. These grasses can form very thick and monospecific stands eliminating other species of herbs, shrubs and trees. Only some bamboos, such as *Bambusa* sp. and *Melocalamus compactiflorus* can compete and may be present in these tall grasslands. In the primary forest habitat tall grasslands are almost absent and do not cover large areas. In wetlands covered by highly degraded primary woody communities they are capable of great vegetative expansion and coverage. Occurrence of dry-tolerant ferns such as *Dicranopteris dichotoma*, *Gleichenia laevissima*, *G. splendida*, *Hicriopteris chinensis*, *Nephrolepis cordifolia*, *N. falcata*, *N. hirsutula*, *Pteridium aquilinum* s. l. and *Lycopodium squarrosum* as well as some grasses and herbs is typical of the herbaceous groundcover stratum within these forests especially in more or less open places. Herbaceous vines like *Ipomoea* sp., *Lepistemon binectariferum* (*Convolvulaceae*) and *Gynostemma pentaphyllum* (*Cucurbitaceae*) are also common here.

Extinction of woody vegetation causes the formation of medium height grasslands on dry, poor and eroded soils. These grasslands represent one of the final stages of primary vegetation degradation in relatively dry conditions. Medium height turf and tufted grasses, such as *Imperata cylindrica*, *Pogonatherum crinitum*, *Echinochloa* sp., *Eragrostis* spp., *Oplismenus* sp., *Paspalum* sp., *Setaria* sp. are the main dominants in these usually floristically very poor plant communities. Some aboriginal weeds such as *Lactuca indica*, *Gynura barbareaifolia* and terrestrial orchids such as *Spiranthes* or *Peristylus* occasionally occur here. Shrub and tree reproduction may take place on medium tall grasslands, but woody plants normally do not develop well due to the general poverty of the soil and unavailability of light and nutrients. Commonly these secondary grasslands spread considerably at elevations of 800–1500 m a.s.l.

Shorter grasslands are with turf and tufted grasses up to 10–20 cm high stabilized by extensive pasturage are developed under humid mountain conditions at 1500–1800 m a.s.l. Short prostrate grasses such as *Pogonatherum crinitum*, species of *Eragrostis* and *Digitaria*, as well as sedges such as *Kyllinga* and *Fimbristylis* occupy about 70–80% of the ground surface in these plant associations. The occurrence here of numerous herbs such as *Centella asiatica*, *Cynoglossum zeylanica*, *Eryngium foetidum*, *Hydrocotyle* sp., *Juncus articulatus*, *Lysimachia peduncularis*, *Pratia begoniifolia*, *Plantago asiatica*, *Viola inconspicua*, *V. philippica*, *V. sumatrana*, *V. tonkinensis* and *V. unwinii* sometimes gives these grasslands a superficial physiognomic resemblance to the mountain meadows of temperate Asia. Dense thickets composed of climbing thorny shrubs like *Uncaria* sp., *Rubus obcordatus*, *R. niveus*, *R. corchorifolius*, *R. asper* and *Hypericum uralum* are occasionally scattered in these grasslands.

Near the summits of numerous mountain systems in the Central Annamese floristic province, particularly at elevations above 2000 m a.s.l., montane forests are gradually replaced by broad-leaved and mixed very wet cloud forests. These are predominantly distributed at 2300–2500 m well above the montane forest belt and give way to tuft-tree thickets on the tops of mountain ridges and peaks. Winter temperatures of these high elevation areas fall a few degrees below zero defining and affecting the relatively low diversity and specific nature of the floristic composition. The vertical structure of these forests usually consists of only three layers — tree, shrub and herbaceous tiers. The first level is composed of usually gnarled trees about 8–12 m high densely covered with epiphytic mosses and thin leaved ferns such as *Hymenophyllum exsertum*, *H. poilanei*, *Macroglena gemmatum*, *Mecodium badium*, *Trichomanes* sp. and *Vandenboschia auriculata* (*Hymenophyllaceae*). Epiphytic orchids are not abundant here. Most common codominants in the canopy stratum of cloud forests are *Rhododendron* spp., *Symingtonia populnea*, *Sorbus* sp., *Diplopanax vietnamensis*, etc. Representatives of *Fagaceae*, commonly observed at lower elevations, are rare here. The shrub level is poorly defined and represented by some species of *Acanthaceae*. On tufted interwoven tree branches and roots there exist numerous mosses, including occasional *Sphagnum* cushions. Herbs in the undergrowth are represented by

species of *Melastomataceae* and *Gesneriaceae*, as well as some ferns and the terrestrial orchids *Goodyera foliosa* and *G. schlechtendaliana*.

Primary, tuft-tree thickets usually cover the tops of ridges and mountain peak in this area at elevations above 2000 m a.s.l. This type of vegetation is developed under climatic conditions where night winter temperatures fall to some degrees below zero. These conditions encourage the presence of some deciduous tree and shrub taxa. However, evergreen broad-leaved forms with rigid coriaceous leaves are dominant. These thickets consist of very densely intertwined and branched gnarled trees and shrubs 2–4 m tall. The most common species here belong to the *Ericaceae* including *Rhododendron lyi*, *R. irroratum*, *R. viali*, *Lyonia ovalifolia*, *Vaccinium chuni*, *V. dunalianum*, *V. sprengelii* and *Gaultheria leucocarpa*, which are accompanied by medium tall bamboo *Arundinaria* sp. Representatives of other families in this plant community are *Ilex crenata* (*Aquifoliaceae*), *Sorbus wattii*, *Stranvaesia davidiana* (*Rosaceae*), *Elaeocarpus darlacensis* (*Elaeocarpaceae*), *Michelia* sp. (*Magnoliaceae*), *Skimmia japonica* and *S. arborescens* (*Rutaceae*). Species of tropical oaks such as *Quercus langbianensis* and *Lithocarpus vidaliana* are sometimes present, but are relatively rare here.

The undergrowth consists of numerous species of mosses dominated by taxa of *Sphagnum*. Very common are terrestrial fruticose lichens, especially species of *Cladonia*. Epiphytic mosses and lichens are also abundant in these highland thickets. The only terrestrial herbs commonly occurring here are *Goodyera foliosa* and *G. schlechtendaliana* and in more or less open places *Cymbidium insigne* is not rare. Often in mountain tuft-tree areas emergent very old stocky and branched individuals of *Pinus dalatensis* reaching 10–12 m in height occur.

In highland areas of the Central Annamese floristic province many representatives of temperate and subtropical Holarctic genera occur, emphasizing the connection of this flora with that of the Holarctic realm. Among species of this group are representatives of the following families and genera:

<i>Aceraceae</i> (<i>Acer</i>),	<i>Lycopodiaceae</i> (<i>Lycopodium</i>),
<i>Actinidiaceae</i> (<i>Actinidia</i>),	<i>Orchidaceae</i> (<i>Amitostigma</i> , <i>Goodyera</i>
<i>Apiaceae</i> (<i>Sanicula</i>),	<i>Platanthera</i> , <i>Pleione</i>),
<i>Araceae</i> (<i>Acorus</i> , <i>Arisaema</i>),	<i>Plantaginaceae</i> (<i>Plantago</i>),
<i>Araliaceae</i> (<i>Panax</i>),	<i>Poaceae</i> (<i>Digitaria</i> , <i>Echinochloa</i> ,
<i>Asteraceae</i> (<i>Gnaphalium</i> , <i>Inula</i> , <i>Sonchus</i>),	<i>Eragrostis</i> , <i>Oplismenus</i> , <i>Setaria</i>),
<i>Betulaceae</i> (<i>Betula</i> , <i>Carpinus</i>),	<i>Polypodiaceae</i> s. l. (<i>Athyrium</i> , <i>Diplazium</i> ,
<i>Boraginaceae</i> (<i>Cynoglossum</i>),	<i>Dryopteris</i> , <i>Polystichum</i> , <i>Thelypteris</i>),
<i>Brassicaceae</i> (<i>Cardamine</i> , <i>Rorippa</i>),	<i>Primulaceae</i> (<i>Lysimachia</i>),
<i>Caprifoliaceae</i> (<i>Lonicera</i> , <i>Viburnum</i>),	<i>Ranunculaceae</i> (<i>Anemone</i>),
<i>Celastraceae</i> (<i>Euonymus</i>),	<i>Rosaceae</i> (<i>Eriobotrya</i> , <i>Malus</i> , <i>Sorbus</i> ,
<i>Chloranthaceae</i> (<i>Chloranthus</i>),	<i>Stranvaesia</i>),
<i>Convallariaceae</i> (<i>Disporum</i> , <i>Polygonatum</i>),	<i>Salicaceae</i> (<i>Salix</i>),
<i>Cornaceae</i> (<i>Cornus</i>),	<i>Saxifragaceae</i> (<i>Astilbe</i>),
<i>Cyperaceae</i> (<i>Bulbostylis</i> , <i>Carex</i> ,	<i>Trilliaceae</i> (<i>Paris</i>),
<i>Eleocharis</i>),	<i>Ulmaceae</i> (<i>Ulmus</i>),
<i>Ericaceae</i> (<i>Gaultheria</i> , <i>Lyonia</i> ,	<i>Valerianaceae</i> (<i>Valeriana</i>),
<i>Rhododendron</i> , <i>Vaccinium</i>),	<i>Violaceae</i> (<i>Viola</i>).
<i>Juncaceae</i> (<i>Juncus</i>),	

The flora of the Central Annamese floristic province is very rich and includes numerous endemic plant species. Many of them are exclusively inhabitants of mountain areas having a high level of annual precipitation, the highest recorded within Indochina (Fig. 2). One endemic genus of flowering plants *Oligoceras* (*Euphorbiaceae*) is reported from this floristic province. Like other floristic provinces of Indochina this area still conceals a great number of exciting future findings. According to available data about 28.4% of all Vietnamese endemics occur in the North

Indochinese Province with 10.8% of these as local endemics of this province (Fig. 4). Selected families with endemic taxa are listed as follow:

- Anacardiaceae* (*Semecarpus anacardiopsis*, *S. annamensis*, *S. humilis*, *S. perniciosus*, *S. velutina*),
Annonaceae (*Artabotrys aeneus*, *A. harmandii*, *A. phuongianus*, *A. tetramerus*, *Cyathocalyx annamensis*, *Goniothalamus albiflorus*, *G. elegans*, *G. multiovulatus*, *Meiogyne subsessilis*, *Melodorum kontumense*, *Orophea desmos*, *Phaeanthus vietnamensis*, *Polyalthia barenensis*, *P. clemensorum*, *Uvaria dac*),
Apiaceae (*Hydrocotyle pseudosanicula*),
Araceae (*Amorphophallus arnautovii*, *Amorphophallus glossophyllus*, *A. rhizomatosus*, *Pothos penicilliger*, *P. touranensis*, *Raphidophora sulcata*, *Schismatoglottis cadieri*, *Typhonium bachmaense*, *T. huense*),
Araliaceae (*Dendropanax venosus*, *Macropanax simplicifolius*, *M. skvortsovae*, *M. vidalii*, *Schefflera alongensis*, *Sch. kontumensis*, *Sch. quangtriensis*, *Sch. quangtriensis*, *Sch. vidaliana*, *Sch. violae*),
Bignoniaceae (*Radermachera eberhardtii*),
Combretaceae (*Anogeissus rivularis*, *Terminalia harmandii*),
Connaraceae (*Rourea acropetala*),
Cornaceae (*Mastixia poilanei*),
Euphorbiaceae (*Baccaurea harmandii*, *B. oxycarpa*, *Breynia grandiflora*, *Cleidion sathayensis*, *Cleistanthus eberhardtii*, *Croton cubiensis*, *C. potabilis*, *C. sathayensis*, *C. touranensis*, *Epiprinus poilanei*, *Flueggea spirei*, *Glochidion bachmaense*, *Mallotus canii*, *M. eberhardtii*, *M. poilanei*, *M. sathayensis*, *Oligoceras eberhardtii*, *Phyllanthus annamensis*, *Ph. carinarius*, *Ph. pireyi*, *Ph. ruber*, *Ph. rubescens*, *Ph. thalii*, *Ph. touranensis*, *Ph. tui*, *Sapium cochinchinensis*),
Fabaceae (*Bauhinia clemensiorum*, *Dunbaria thorelii*, *Ophrestia laotica*),
Moraceae (*Artocarpus melinoxylus*, *Ficus kontumensis*),
Myrsinaceae (*Ardisia argentea*, *A. florida*, *A. harmandii*, *A. incrassata*, *A. ixoraefolia*, *A. lecomtei*, *A. maxima*, *A. miniata*, *A. pseudo-pedunculosa*, *A. roseiflora*),
Passifloraceae (*Adenia banaensis*),
Podostemaceae (*Dalzellia carinata*),
Primulaceae (*Lysimachia chenii*),
Proteaceae (*Helicia stenophylla*),
Rosaceae (*Photinia moiorum*),
Sabiaceae (*Meliosma cinerea*, *M. clemensiorum*, *M. kontumensis*, *M. quangnamensis*, *M. spathulata*, *Sabia kontumensis*),
Sapotaceae (*Eberhardtia krempfii*, *Palaquium annamense*, *P. poilanei*, *Sarcosperma affinis*, *S. kontumense*),
Scrophulariaceae (*Adenosma annamensis*, *Brandisia annamica*, *Lindernia eberhardtii*),
Styracaceae (*Styrax litseoides*, *S. rufopilosus*),
Symplocaceae (*Symplocos disepala*),
Taxaceae (*Amentotaxus poilanei*),
Theaceae (*Adinandra grandifolia*, *Camellia corallia*, *C. elongata*, *C. gaudichaudii*, *Gordonia gigantiflora*),
Thymelaeaceae (*Aquilaria banaensis*, *Wikstroemia poilanei*).

About 335 orchid species from 99 genera are known from the Central Annamese Province. Twenty-one species are local endemics of this area (Table 7).

Table 7. Orchid species reported from the Central Annamese floristic province (local endemics of this area in bold)

<i>Acampe bidoupense</i> ,	<i>Aerides falcata</i> ,	<i>Amitostigma keiskeoides</i> ,
<i>Acanthephippium striatum</i> ,	<i>A. odorata</i> ,	<i>Anoectochilus acalcaratus</i> ,
<i>Acriopsis indica</i> ,	<i>Agrostophyllum brevipes</i> ,	<i>A. lylei</i> ,
<i>A. liliifolia</i> ,	<i>A. callosum</i> ,	<i>A. roxburghii</i> ,

- A. siamensis*,
Aphyllorchis annamensis,
A. evrardii,
Apostasia wallichii,
Appendicula gracilis,
A. cornuta,
A. hexandra,
Arundina chinensis,
A. graminifolia,
Ascocentrum garayi,
Ascolabium pusillum,
Brachycorythis laotica,
Bulbophyllum affine,
B. ambrosia,
B. astelidum,
B. averyanovii,
B. blepharistes,
B. careyanum,
B. catenarium,
B. crassiusculifolium,
B. elassonotum,
B. fischeri,
B. flaviflorum,
B. frostii,
B. hiepii,
B. hirtum,
B. hymenanthum,
B. kanburiense,
B. lemniscatoides,
B. longiflorum,
B. monanthum,
B. ngoclinensis,
B. odoratissimum,
B. orectopetalum,
B. orientale,
B. pecten-veneris,
B. picturatum,
B. poilanei,
B. refractum,
B. reptans,
B. retusiusculum,
B. sigaldiae,
B. smitinandii,
B. thaiorum,
B. tixieri,
B. tortuosum,
B. tripudians,
Calanthe alismifolia,
C. angusta,
C. angustifolia,
C. argenteo-striata,
C. cardioglossa,
C. chevalieri,
C. clavata,
C. lyroglossa,
C. triplicata,
Callostylis rigida,
Cephalantheropsis longipes,
C. obcordata,
Ceratostylis siamensis,
C. subulata,
Cheirostylis cochinchinensis,
Cleisostoma arietinum,
C. birmanicum,
C. discolor,
C. duplicilobum,
C. equestre,
C. fuerstenbergianum,
C. paniculatum,
C. racemiferum,
C. rostratum,
C. striatum,
C. williamsonii,
Coelogyne assamica,
C. calcicola,
C. cycnoches,
C. eberhardtii,
C. fimbriata,
C. lentiginosa,
C. mooreana,
C. rigida,
C. sanderae,
C. schultesii,
C. stricta,
C. viscosa,
Collabium chinense,
Corymborkis veratrifolia,
Cryptostylis arachnites,
Cymbidium aloifolium,
C. atropurpureum,
C. banaense,
C. bicolor,
C. dayanum,
C. eburneum,
C. ensifolium,
C. finlaysonianum,
C. insigne,
C. lancifolium,
C. schroederi,
C. sinense,
C. wilsonii,
Cyrtosia javanica,
Dendrobium acinaciforme,
D. amabile,
D. bellatulum,
D. cariniferum,
D. christyanum,
D. chrysanthum,
D. chrysotoxum,
D. crumenatum,
D. crystallinum,
D. delacourii,
D. dentatum,
D. devonianum,
D. draconis,
D. ellipsophyllum,
D. farmeri,
D. faulhaberianum,
D. gratiosissimum,
D. hercoglossum,
D. heterocarpum,
D. hymenanthum,
D. indivisum,
D. lindleyi,
D. lituiflorum,
D. multilineatum,
D. nobile,
D. ochraceum,
D. oxyphyllum,
D. pachyglossum,
D. palpebrae,
D. parcum,
D. parishii,
D. podagraria,
D. porphyrophyllum,
D. pseudotenellum,
D. pulchellum,
D. salaccense,
D. secundum,
D. terminale,
D. thyrsoiflorum,
D. tortile,
D. truncatum,
D. unicum,
D. uniflorum,
D. virgineum,
D. wattii,
D. williamsonii,
Didimoplexiopsis
khiriwongensis,
Didimoplexis pallens,
Doritis pulcherrima,
Epigeneium cacuminis,

- E. chapaense*,
E. clemensiae,
E. labuanum,
Epipactis atromarginata,
Eria acervata,
E. amica,
E. boniana,
E. carunculosa,
E. corneri,
E. coronaria,
E. eriopsidobulbon,
E. globifera,
E. globulifera,
E. lasiopetala,
E. obscura,
E. paniculata,
E. pannea,
E. perpusilla,
E. siamensis,
E. spirodela,
E. thao,
Erythrorchis ochobiensis,
Eulophia macrobulbon,
Flickingeria angustifolia,
F. fimbriata,
F. forcipata,
F. ritaeana,
Galeola nudifolia,
Gastrochilus calceolaris,
G. hainanensis,
G. pseudodistichus,
G. simplicilabius,
Geodorum attenuatum,
G. densiflorum,
G. pulchellum,
Goodyera foliosa,
G. fumata,
G. procera,
G. schlechtendaliana,
Habenaria acuífera,
H. mandersii,
H. medioflexa,
H. pantlingiana,
H. reflexa,
H. rhodocheila,
H. viridiflora,
Holcoglossum subulifolium,
Hygrochilus parishii,
Kingidium deliciosum,
Lecanorchis javanica,
Liparis acuminata,
L. averyanoviana,
L. bootanensis,
L. cespitosa,
L. crassibasis,
L. elliptica,
L. luteola,
L. nervosa,
L. paradoxa,
L. sutepensis,
Ludisia discolor,
Luisia morsei,
L. psyche,
Malaxis finetii,
M. ophridis,
Malleola seidenfadenii,
Micropera poilanei,
Mischobulbon cordifolium,
M. ovalifolium,
M. wrayanum,
Monomeria barbata,
M. dichroma,
Nephelaphyllum tenuiflorum,
Nervilia aragoana,
N. crociformis,
Neuwiedia inae,
Oberonia anthropophora,
O. caulescens,
O. dolichocaulis,
O. emarginata,
O. ensiformis,
O. evrardii,
O. falcata,
O. longibracteata,
O. mucronata,
O. pachyphylla,
O. rasmussenii,
O. rosea,
O. tixieri,
Odontochilus poilanei,
Ornithochilus difformis,
Otochilus fuscus,
Panisea tricallosa,
Paphiopedilum appletonianum,
P. callosum,
Parapteroceras elobe,
Pennilabium angraecum,
Peristylus goodyeroides,
Phaius flavus,
P. indochinensis,
P. longicornu,
Phalaenopsis fuscata,
P. lobbii,
P. mannii,
Pholidota articulata,
P. chinensis,
P. convallariae,
P. guibertiae,
P. imbricata,
P. levelleana,
P. pallida,
P. recurva,
P. rubra,
P. ventricosa,
Phreatia densiflora,
P. formosana,
Platanthera angustata,
Pleione praecox,
P. vietnamensis,
Podochilus microphyllus,
Polystachya concreta,
Pomatocalpa spicata,
Porpax reticulata,
Pristiglottis umbrosa,
Pteroceras leopardinum,
P. semiteretifolium,
P. simondianum,
Renanthera coccinea,
Rhomboda tokioi,
Rhynchostylis gigantea,
Schoenorchis brevirachis,
S. eberhardtii,
S. gemmata,
Spiranthes sinensis,
Staurochilus fasciatus,
Sunipia annamensis,
S. scariosa,
Taeniophyllum fasciculatum,
T. pahangense,
Tainia angustifolia,
T. hongkongensis,
T. hookeriana,
T. latifolia,
T. pauciflora,
T. viridifusca,
Thecopus maingayi,
Thecostele alata,
Thelasis pygmaea,
Thrixspermum amplexicaule,
T. annamense,
T. calceolus,
T. carnosum,
T. centipeda,

<i>T. formosanum,</i>	<i>T. microphylla,</i>	<i>V. lilacina,</i>
<i>T. pauciflorum,</i>	<i>T. pulvinata,</i>	<i>V. pumila,</i>
<i>T. poilanei,</i>	<i>T. velutina,</i>	<i>Vanilla annamica,</i>
<i>Trias disciflora,</i>	<i>Tropidia angulosa,</i>	<i>V. pierrei,</i>
<i>T. nasuta,</i>	<i>T. curculigoides,</i>	<i>Zeuxine nervosa,</i>
<i>Trichotosia dasyphylla,</i>	<i>Vanda concolor,</i>	<i>Z. parvifolia.</i>

The estimated total number of orchids occurring in this floristic province may approach 400–450 species.

7.5. South Annamese Province

The extreme southern part of the Truong Son or Annamite Range running into the Indochinese Peninsula from north to south along the western border with Vietnam contains a number of uplifted plateaux and high mountain systems. This isolated highland area is clearly demarcated by the distribution of numerous endemic species within the South Annamese floristic province (Fig. 3). Geographically the South Annamese floristic province includes Lam Vien (Dalat), Mo Nong (Djiring) and Di Linh Plateaux and some highland areas adjoining these regions. A number of high ridges and large mountain systems are associated with the high plateaux of the South Annamese floristic province, the highest peaks being Chu Dang Sin (2405 m), Bidup (2287 m), Lang Bian (2163 m) and Nui Vong Phu (Mere et l'Enfant, 2051 m). From the south, west and north the isolated highland area of the province is bounded by the lowlands of the Mekong, Krong Ana and Da Rang (Cheo Reo Depression) rivers basins, as well as by the hill area of the lowland coastal plain on the east. A relatively small area of the province lies entirely within Vietnam and includes the highland mountain regions of Dac Lac, Khanh Hoa, Lam Dong, Ninh Thuan, Binh Phuoc, Dong Nai and Binh Thuan administrative provinces. Most areas of the South Annamese floristic province lie above 600–700 m a.s.l.

Plateaux within the territory of the South Annamese floristic province represent distinct solid blocks of ancient basement plate composed of Precambrian gneiss uplifted to 1500 m a.s.l. Outcrops of this ancient gneiss (as well as Paleozoic and Mesozoic granites that covered the basement rocks) appear as a steep cliff facing the sea. This cliff represents a section of ancient Indochina basement rock exposed by a great geological fault and now forms the coastline. In many places these cliffs reach more than 1200 m high and delimit the southeastern boundary of the province. This area contains many narrow canyons and showy waterfalls. Rivers here are relatively short and can flow rapidly during torrential rains.

Marine and continental sediments, alluvial masses and basalts of different ages cover the basement rocks of the uplifted plateaux in the province. Extensive lava flows along the margin of the plateaux are observable in many places. The area was consolidated by numerous granite intrusives that cover the basement rocks. Occasional granite outcrops and chains of highly eroded volcanic cones are present throughout the area (Schzeglova 1957; Rundel 1999).

High mountain systems rising within the territory are plateaux composed mainly of granite. Various combinations of quartzite, rhyolites, andesites and dacites, as well as metamorphic rocks such as schist, clay or quartzitic sandstone and slate are also common (Rundel 1999). The mountain systems show the effects of intensive current erosion and have characteristically flat-topped peaks.

A monsoon tropical climate with warm winter and summer rains is typical over the largest areas of the South Annamese floristic province (Fig. 1). Rainfall occurs here in June–September and the winter is the dry season. However in a narrow belt along the eastern border of the province, the peak of rainfall is shifted to September–December with the dry period lasting from February until August. This area is characterized as having a monsoon tropical climate with warm winter and autumn–winter rains (Nguyen Khanh Van *et al.* 2000). Mean annual precipitation varies in the area between 1500 and 3000 mm. Mean temperatures are dependent on elevation. At

500–1000 m mean summer temperatures are between 23–25° C and at 1500 m they are about 19–20° C. Mean winter temperatures in the area are 19–23° C and 16–18° C respectively. Highland regions of the South Annamese floristic province below 1500 m a.s.l. are characterized as having a monsoon tropical climate associated with mountains (Nguyen Khanh Van *et al.* 2000). Lower mean temperatures are typical of these mountain regions. Winter temperatures are 16–18° C and not rarely fall to near 10° C in the coldest month, February. The absolute temperature minimum recorded at 1500 m is –0.1° C. Mean annual precipitation usually varies in the highlands of the area from 2000 to 5000 mm with annual rainfall maximum (5232 mm) reported for Hon Ba station near Nui Vong Phu peak at 1484 m a.s.l. (Nguyen Khanh Van, pers. comm.). The peak of rainfall in these mountains is in summer or autumn. Winter is relatively dry, but clouds and drizzle are common and maintain a constant high humidity.

Closed evergreen montane broad-leaved forests, mixed closed forest with some coniferous species, and coniferous woodlands occupy the largest areas of the North Indochinese floristic province. Closed evergreen montane broad-leaved forests represent the most common type of primary vegetation in the North Indochinese floristic province. These forests are commonly observed on mid-elevation slopes composed of silicate rocks mostly at 700–1200(1500) m a.s.l. Their upper canopy reaches to 25–30 (35) m in height and these heights decrease with increasing elevation and with decreasing soil depth. Most common representatives of the upper forest stratum observed here belong to the following families:

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|---|---|
| <i>Aceraceae</i> (<i>Acer labellatum</i> , <i>A. oblongum</i>), | <i>Hamamelidaceae</i> (<i>Rhodoleia championii</i> , |
| <i>Burseraceae</i> (<i>Canarium</i> sp.), | <i>Symingtonia populnea</i>), |
| <i>Clusiaceae</i> (<i>Calophyllum thorelii</i> , <i>Garcinia</i> | <i>Lauraceae</i> (<i>Actinodaphne cochinchinensis</i> , |
| spp.), | <i>A. pilosa</i> , <i>Cinnamomum burmanii</i> , |
| <i>Dipterocarpaceae</i> (<i>Dipterocarpus hasseltii</i>), | <i>C. cassia</i> , <i>C. iners</i> , <i>C. litseaefolium</i> , |
| <i>Elaeocarpaceae</i> (<i>Elaeocarpus</i> spp.), | <i>C. obtusifolium</i> , <i>C. validinerve</i> , |
| <i>Fagaceae</i> (<i>Castanopsis chevalieri</i> , | <i>C. zeylandicum</i> , <i>Lindera chenii</i> , |
| <i>C. dongchoënsis</i> , <i>C. echinocarpa</i> , | <i>L. balansae</i> , <i>L. cubeba</i> , <i>L. glutinosa</i> , |
| <i>C. ferox</i> , <i>C. indica</i> , <i>C. nhatrangensis</i> , | <i>L. polyantha</i> , <i>L. thorelii</i> , <i>Machilus</i> |
| <i>C. wilsoni</i> , <i>Lithocarpus agaregalum</i> , | <i>chinensis</i> , <i>M. odoratissimus</i> , <i>Neolitsea</i> |
| <i>L. annamicorum</i> , <i>L. auriculata</i> , | <i>poilanei</i> , <i>N. zeylanica</i> , <i>Notophoebe</i> sp., |
| <i>L. bacgiangensis</i> , <i>L. echinophorus</i> , | <i>Phoebe cuneata</i>), |
| <i>L. harmandii</i> , <i>L. megastachya</i> , <i>L. spicata</i> , | <i>Magnoliaceae</i> (<i>Magnolia</i> sp., <i>Manglietia</i> |
| <i>L. sylvicolarum</i> , <i>L. tenuinervis</i> , | <i>duclouxii</i> , <i>Michelia constricta</i> , <i>Talauma</i> |
| <i>L. trachycarpa</i> , <i>L. truncata</i> , | <i>hodgsonii</i>), |
| <i>L. xylocarpus</i> , <i>Quercus angustinii</i> , | <i>Moraceae</i> (<i>Ficus</i> spp.), |
| <i>Q. braianensis</i> , <i>Q. chapensis</i> , | <i>Sapindaceae</i> (<i>Lepisanthes langbianensis</i> , |
| <i>Q. dongnaiensis</i> , <i>Q. erioclada</i> , | <i>Xerospermum donnaiensis</i>), |
| <i>Q. langbianensis</i> , <i>Q. quangtriensis</i> , | <i>Theaceae</i> (<i>Camellia langbianensis</i> , <i>C. tsaii</i> , |
| <i>Q. schottkyana</i>), | <i>Gordonia</i> sp., <i>Pyrenaria poilanei</i> , |
| <i>Juglandaceae</i> (<i>Engelhardtia</i> sp.), | <i>Schima crenata</i> , <i>S. wallichii</i>). |

Gymnosperm species also occasionally may be seen here. Among them are large trees of the first canopy stratum including *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Nageia wallichiana* and *Podocarpus neriifolius* (*Podocarpaceae*), and small underwood treelets such as *Calocedrus macrolepis* (*Cupressaceae*), *Cephalotaxus mannii* (*Cephalotaxaceae*) and *Taxus wallichiana* (*Taxaceae*).

In the second forest stratum composed of trees 15–25 m tall species of the following families may commonly be seen in this area:

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|---|---|
| <i>Aceraceae</i> (<i>Acer heptaphlebium</i>), | <i>Araliaceae</i> (<i>Dendropanax chevalieri</i> , |
| <i>Anacardiaceae</i> (<i>Choerospondias axillaris</i>), | <i>Heteropanax fragrans</i> , <i>Macropanax</i> |
| <i>Aquifoliaceae</i> (<i>Ilex</i> sp.), | <i>concinnum</i> , <i>Schefflera</i> spp.), |

- Betulaceae* (*Carpinus viminea*),
Clusiaceae (*Garcinia* spp.),
Elaeocarpaceae (*Elaeocarpus kontumensis*),
Ericaceae (*Rhododendron* spp., *Vaccinium*
iteophyllum, *V. viscifolium*),
Fabaceae (*Archidendron chevalieri*,
A. clypearia)
Fagaceae (*Lithocarpus* spp.),
Flacourtiaceae (*Scolopia* sp.),
Illiciaceae (*Illicium griffithii*,
I. cambodianum),
Lauraceae (*Cinnamomum* sp., *Litsea*
lancifolia),
Magnoliaceae (*Magnolia* sp., *Manglietia*
spp., *Michelia subulifera*, *Michelia* spp.),
Moraceae (*Ficus* spp.),
Sabiaceae (*Meliosma lepidota*, *Meliosma*
sp.),
Sterculiaceae (*Heritiera* sp., *Sterculia*
nobilis),
Rosaceae (*Malus doumeri*, *Photinia*
prunifolia, *Prunus javanica*, *Pygeum* sp.,
Sorbus corymbifera),
Styracaceae (*Styrax annamensis*),
Symplocaceae (*Symplocos adenophylla*,
Symplocos spp.),
Theaceae (*Eurya trichocarpa*, *Ternstroemia*
kwangtungensis).

The underwood stratum of treelet and shrub species is dominated in broad-leaved mountain forests of the area by numerous species. Most common of them belong to the following families:

- Aceraceae* (*Acer oblongum*),
Araliaceae (*Dendropanax chevalieri*,
Schefflera spp.),
Celastraceae (*Euonymus laxiflorus*),
Clusiaceae (*Garcinia* spp.),
Ericaceae (*Rhododendron* spp., *Vaccinium*
viscifolium),
Icacinaceae (*Gomphandra* sp.),
Illiciaceae (*Illicium tenuifolium*),
Lauraceae (*Litsea lancifolia*),
Melastomataceae (*Allomorphia inaequata*,
Blastus borneënsis, *Poilannammia*
allomorphioidea, *P. incisa*,
Pseudodissochaeta septentrionalis),
Myrsinaceae (numerous species of *Ardisia*),
Pittosporaceae (*Pittosporum merrillianum*,
P. glabratum),
Rosaceae (*Eriobotrya poilanei*),
Rubiaceae (numerous species of *Lasianthus*,
Psychotria langbianensis, *P. rubra*).
Rutaceae (*Euodia callophylla*, *Skimmia*
arborescens),
Sabiaceae (*Meliosma lepidota*),
Saxifragaceae (*Dichroa febrifuga*, *Polyosma*
annamensis, *P. nhatrangensis*),
Symplocaceae (*Symplocos* spp.),
Theaceae (*Anneslea fragrans*, *Gordonia*
bidoupensis).

Occasionally a variety of shorter stature palms such as *Licuala bracteata*, *L. fatua*, *L. glaberrima*, *L. hexasepala*, *Pinanga banaënsis*, *P. duperreana* and *P. quadrijuga*, as well as woody tree ferns such as *Cibotium barometz*, *Cyathea contaminans*, *C. gigantea*, *C. podophylla*, *C. salletti* and *Ctenitopsis austro-sinensis* are important components of these forests. Some individuals of *Cyathea* may reach 10 or more m in height. Giant herbs such as *Musa bakeri* (*Musaceae*) and *Alpinia* spp., *Amomum* spp. and *Hedychium* spp. (*Zingiberaceae*) are also common in these forests especially in open places along streams.

Terrestrial ferns and herbs in closed mountain forests often cover only 10% or less of the forest floor. The most common species here belong to the following families and genera:

- Acanthaceae* (*Staurogyne major*,
Strobilanthes spp.),
Araceae (*Aglaonema* sp., *Amorphophallus*
sp., *Arisaema* spp.),
Aspidiaceae (*Arachniodes* spp., *Polystichum*
spp., *Pteridrys* spp., *Rumohra* spp.),
Begoniaceae (*Begonia* spp.),
Chloranthaceae (*Chloranthus erectus*),
Lycopodiaceae s. l. (*Huperzia serrata*),
Melastomataceae (*Phyllagathis*
megalocentra, *Sonerila annamitica*),
Orchidaceae (*Acanthephippium striatum*,
Anoectochilus setaceus, *Calanthe*
angustifolia, *C. clavata*, *C. velutina*,
Cephalantheropsis obcordata,
Cryptostylis arachnites, *Cymbidium*
lancifolium, *Goodyera foliosa*, *Phaius*
flavus),

Pentaphragmataceae (*Pentaphragma gamopetalum*, *P. honbaense*, *P. sinensis*),
Plagiogyriaceae (*Plagiogyria* spp.),
Polygalaceae (*Polygala karensium*, *P. pyrolloides*),

Pteridaceae (*Pteris* spp.),
Rubiaceae (*Argostemma* spp., *Hedyotis* spp., *Ophiorrhiza* spp.),
Zingiberaceae (*Alpinia* spp., *Amomum* spp.).

Large woody lianas are common in montane forests. Among the most prevalent species are *Actinidia latifolia* (*Actinidiaceae*), *Alyxia pseudochina*, *Alyxia* spp. (*Apocynaceae*), *Ancistrocladus cochinchinensis* (*Ancistrocladaceae*), *Calamus* spp. (*Arecaceae*), *Gnetum montanum* (*Gnetaceae*), *Kadsura coccinea* (*Schisandraceae*), *Smilax* spp. (*Smilacaceae*), *Stauntonia cavaleriana* (*Lardizabalaceae*) and *Tetrastigma* spp. (*Vitaceae*). Also very common in montane forests are epiphytes, especially ferns (numerous species of *Aspleniaceae*, *Elaphoglossaceae*, *Grammitidaceae*, *Hymenophyllaceae*, *Polypodiaceae*, *Vittariaceae*) and orchids *Bulbophyllum crassiusculifolium*, *B. hymenanthum*, *B. retusiusculum*, *B. tixieri*, *Ceratostylis radiata*, *C. subulata*, *Coelogyne sanderae*, *Dendrobium virgineum*, *Epigeneium amplum*, *E. cacuminis*, *Eria amica*, *E. bipunctata*, *E. floribunda*, *E. globifera*, *E. paniculata*, *E. pannea*, *E. siamensis*, *E. thao*, *Flickingeria ritaeana*, *Gastrochilus calceolaris*, *Holcoglossum subulifolium*, *Otochilus fuscus*, *Pholidota chinensis*, *P. leveilleana* and *Sunipia annamensis*. Occasionally some epiphytic shrubs such as *Rhododendron* spp., *Schefflera tribracteata* and *Vaccinium dunalianum* and epiphitic vines such as *Aeschynanthus moningeriae*, *A. poilanei*, *Medinilla alternifolia* and *Piper* spp. also occur. Occasionally in shady places within this area some rare saprophytes may be found, including *Monotropastrum pumilum*, *Petrosavia sinii*, *Sciaphila clemensiae* and the ground root parasites *Balanophora abbreviata*, *B. fugosa* and *Rhopalocnemis phalloides*. The canopies of the tallest trees are the habitats of a number of common parasitic shrubs such as *Helixanthera coccinea*, *H. parasitica*, *H. pierrei*, *Loranthus* sp., *Macrosolen annamicus*, *Macrosolen* sp., *Taxillus delavayi* (*Loranthaceae*), *Dendrotrophe buxifolia*, *D. frutescens*, *D. umbellata* (*Santalaceae*) and *Viscum ovalifolium* (*Viscaceae*).

Conifers play an increasingly important role in the canopy of humid montane forests at above 1500 m a.s.l. especially near ridge peaks and mountain summits. In these highland humid conditions mixed forests are formed. Species of the *Fagaceae*, *Lauraceae*, *Magnoliaceae* and *Theaceae* provide much of the canopy cover in these forests. However large conifers are usual emergents above a matrix of broad-leaved trees. Main coniferous dominants here are *Fokienia hodginsii*, *Pinus dalatensis*, *P. krempfii* and *P. wangii*. All of these taxa are very large trees, growing to 45 m in height and 2 m in diameter, and have been recorded as more than 1000 years old. Sometimes other gymnosperm trees such as *Cephalotaxus mannii*, *Dacrycarpus imbricatus*, *Dacrydium elatum*, *Keteleeria evelyniana*, *Nageia fleuryi*, *N. wallichiana* and *Podocarpus nerifolius* also form integral component of these forests, but rarely reach the first canopy stratum. The flora of the lower forest strata in coniferous, needle-leaved mixed forests has similar structure and species composition to that observed in broad-leaved forests.

The higher mountains of the South Annamese floristic province are exposed to humid winds and are frequently bathed in moist clouds. The abundant dew and fog in these areas compensates for the lack of rainfall during the short dry season, resulting in very wet conditions within these mossy cloud forests. Soils here are rich in highly acidic organic matter. Much of this zone lies above 1800 m a.s.l. The usual dominant elements of this relatively low forest on tops of ridges are various combinations of such conifers as *Dacrydium elatum*, *Fokienia hodginsii*, *Nageia wallichiana*, *Pinus dalatensis*, *P. krempfii*, *P. wangii* and *Podocarpus nerifolius*. Among the most common angiosperm trees here are representatives of *Elaeocarpaceae* (*Elaeocarpus darlacensis*), *Fagaceae* (*Lithocarpus* sp., *Quercus poilanei*, *Quercus* sp.), *Hamamelidaceae* (*Symingtonia populnea*), *Illiciaceae* (*Illicium tenuifolium*), *Magnoliaceae* (*Michelia* sp.), *Rosaceae* (*Sorbus corymbifera*) and *Theaceae* (*Gordonia* sp., *Pyrenaria* sp., *Ternstroemia* sp.). These taxa give way to increasing dominance by *Ericaceae* such as *Lyonia annamense*, *L. chapaensis*, *L. ovalifolia*, *Rhododendron fleuryi*, *Rh. langbianense*, *Rhododendron* sp., *Vaccinium chevalieri*, *V.*

greenwayae, *V. harmandianum* and *V. viscifolium* at higher elevations. Among terrestrial and lithophytic herbs present in these forest are species of *Acanthaceae*, as well as *Ainsliaea* spp. (*Asteraceae*), *Anemone poilanei* (*Ranunculaceae*), *Arisaema balansae* (*Araceae*), *Calanthe angustifolia*, *C. clavata*, *Goodyera schlechtendaliana*, *Nephelaphyllum tenuiflorum* (*Orchidaceae*), *Carex baccans*, *Carex* spp. (*Cyperaceae*), *Hedyotis* spp. (*Rubiaceae*), *Hydrocotyle chinensis* (*Apiaceae*), *Sonerila annamitica* (*Melastomataceae*) and *Viola tonkinensis* (*Violaceae*). Typical lithophytes on mossy vertical cliffs are the orchids *Amitostigma bidupense* and *Bulbophyllum tixierii*. In mountain highlands, open places of rocky outcrops exposed to strong winds are usually covered with dense thickets of *Arundinaria* sp. Epiphytes in cloud forest are abundant. The most of these are bryophytes, ferns (species of families *Grammitidaceae*, *Vittariaceae*, *Hymenophyllaceae*) and orchids such as *Bulbophyllum reptans*, *Ceratostylis radiata*, *Cleisocentron klossii*, *Coelogyne mooreana*, *Epigeneium amplum*, *E. chapaense*, *Eria globifera*, *E. paniculata*, *E. siamensis*, *E. thao*, *Monomeria dichroma*, *Otochilus fuscus*, *Panisea albiflora* and *Sunipia annamensis*.

Open coniferous woodlands are one of the most widespread types of habitats in the South Annamese floristic province. This kind of vegetation is usually regarded as a secondary derived community developed within areas of extinct broad-leaved and mixed montane forests. In a number of districts open coniferous forests more than 80 years old with stands 20–25 (30) m high are integral elements of the modern landscapes of the province. These forests are usually developed on degraded soils of granite and sandy hill slopes between 1000 and 1800 m a.s.l.

Pinus kesiya is the most common dominant of open coniferous woodlands in the South Annamese floristic province between 1000 and 1800 m a.s.l. Occasionally these woodlands occur as low as 800 m on the margin of the semi-deciduous broad-leaved forest zone. At low elevations *Pinus kesiya* is usually replaced by the more tropical *P. merkusii*. Human impact on montane landscapes in the area has almost certainly promoted the expansion of secondary coniferous forests at the expense of former montane evergreen forests. The relatively open canopy of montane pine forests is almost exclusively dominated by *Pinus kesiya* in the South Annamese Province. Other gymnosperm trees like *Keteleeria evelyniana* may be present in denser forests along the margins of these pine stands.

A lower open stratum of small trees and shrubs is present in secondary pine forests, with relatively low diversity. Virtually all these species are adapted to low nutrient conditions of soils developed on well-drained silicate alluvial sands.

Fire encourages pine forest formation. Small seedlings are usually killed by fire, while saplings over 12 years in age are damaged but can survive. Mature pines appear to benefit from fires by the elimination of competing species and reduction of the impact of certain parasites. The woody subcanopy stratum in pine woodlands includes treelet and shrub species of the following families and genera:

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|--|---|
| <i>Anacardiaceae</i> (<i>Rhus javanica</i>), | <i>Hamamelidaceae</i> (<i>Rhodoleia championii</i>), |
| <i>Asteraceae</i> (<i>Leucomeris decora</i>), | <i>Juglandaceae</i> (<i>Engelhardtia spicata</i>), |
| <i>Buddlejaceae</i> (<i>Buddleja asiatica</i>), | <i>Malvaceae</i> (<i>Hibiscus squamosus</i>), |
| <i>Ericaceae</i> (<i>Agapetes bracteata</i> , <i>Agapetes</i> | <i>Myricaceae</i> (<i>Myrica esculenta</i> , <i>M. sapida</i>), |
| sp., <i>Craibiodendron stellatum</i> , | <i>Myrtaceae</i> (<i>Tristania burmannica</i>), |
| <i>C. vietnamense</i> , <i>Lyonia ovalifolia</i> , | <i>Proteaceae</i> (<i>Helicia nilagirica</i>), |
| <i>Vaccinium bracteatum</i> , <i>V. sprengelii</i>), | <i>Rhamnaceae</i> (<i>Rhamnus crenatus</i>), |
| <i>Euphorbiaceae</i> (<i>Phyllanthus emblica</i>), | <i>Rubiaceae</i> (<i>Gardenia sootepensis</i>), |
| <i>Fabaceae</i> (<i>Albizzia attopeuensis</i> , | <i>Styracaceae</i> (<i>Styrax benzoin</i>), |
| <i>Archidendron chevalieri</i> , <i>A. clypearia</i> , | <i>Theaceae</i> (<i>Adinandra</i> sp., <i>Anneslea</i> sp., |
| <i>A. lucidum</i>), | <i>Eurya</i> sp., <i>Schima wallichii</i> , |
| <i>Fagaceae</i> (<i>Lithocarpus dealbata</i> , | <i>Ternstroemia</i> sp.), |
| <i>L. pycnostachys</i> , <i>L. truncatus</i> , <i>Quercus</i> | <i>Ulmaceae</i> (<i>Trema tomentosa</i>), |
| <i>helferiana</i> , <i>Q. lanata</i> , <i>Q. kerrii</i>), | <i>Verbenaceae</i> (<i>Viburnum coriaceum</i>). |

In pine woodlands numerous species of terrestrial herbs and ferns are found. Among the most common ferns are: *Blechnum orientale*, *Brainea insignis* and *Woodwardia cochinchinensis*. Most typical herbs of open pine woodlands belong to the following families:

<p><i>Asteraceae</i> (<i>Anisopappus chinensis</i>, <i>Cirsium lineare</i>, <i>Elephantopus mollis</i>, <i>Erigeron crispus</i>, <i>Piloselloides hirsuta</i>, <i>Sonchus oleraceus</i>), <i>Chloranthaceae</i> (<i>Chloranthus japonica</i>), <i>Cyperaceae</i> (<i>Carex</i> spp., <i>Fimbristylis</i> spp.),</p>	<p><i>Fabaceae</i> (<i>Desmodium griffithianum</i>, <i>Shuteria vestita</i>), <i>Gentianaceae</i> (<i>Gentiana langbianensis</i>), <i>Nepenthaceae</i> (<i>Nepenthes thorelii</i>), <i>Poaceae</i> (<i>Imperata cylindrica</i>, <i>Neyraudia reynaudiana</i>), <i>Polygalaceae</i> (<i>Polygala paniculata</i>).</p>
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Typical ephemeral geophytic herbs here are *Drosera peltata* (*Droseraceae*), *Hypoxis aurea* (*Hypoxidaceae*), *Ophioglossum paucifolium* (*Ophioglossaceae*), *Cymbidium cyperifolium*, *Eulophia spectabilis* and *Spathoglottis pubescens* (*Orchidaceae*). Occasionally small woody and herbaceous lianas such as *Gelsenium elegans* (*Loganiaceae*), *Hoya carnosa*, *H. macrophylla*, *Hoya* sp. (*Asclepiadaceae*), *Smilax* spp. (*Smilacaceae*), *Codonopsis javanica* (*Campanulaceae*) and *Dioscorea* spp. (*Dioscoreaceae*) may be encountered in these forests.

Epiphytes are occasionally abundant and diverse in open montane pine forests. However they regularly inhabit broad-leaved trees. Common epiphytic fern genera such as *Aglaomorpha* (*A. coronans*), *Crypsinus* (*C. trilobus*), *Drynaria*, *Humata*, *Hymenolepis*, *Lepisorus*, *Loxogramme*, *Phymatodes*, *Polypodium* and *Pyrrosia* are widespread. Among the most common epiphytic orchids here are *Bulbophyllum luanii*, *B. pinicolum*, *B. retusiusculum*, *B. semiteretifolium*, *B. umbellatum*, *Cymbidium schroederi*, *Dendrobium bellatulum*, *D. pseudotenellum*, *D. heterocarpum*, *Eria lactiflora*, *E. pannea*, *Panisea tricallosa*, *Pholidota articulata*, *P. leveilleana*, *P. recurva*, *Sunipia pallida*, *Trichotosia dalatensis*, *T. dasyphylla*, *T. microphylla* and *Vanda pumila*.

A relatively small area of the South Annamese floristic province possesses a very diverse and highly specific flora. This isolated mountain region is in the extreme south of the floristic province and includes several species of Holarctic genera from the following families:

<p><i>Aceraceae</i> (<i>Acer</i>), <i>Actinidiaceae</i> (<i>Actinidia</i>), <i>Apiaceae</i> (<i>Bupleurum</i>, <i>Sanicula</i>, <i>Torilis</i>), <i>Araceae</i> (<i>Acorus</i>, <i>Arisaema</i>), <i>Araliaceae</i> (<i>Hedera</i>), <i>Aristolochiaceae</i> (<i>Asarum</i>), <i>Aspidiaceae</i> (<i>Polystichum</i>), <i>Asteraceae</i> (<i>Cirsium</i>, <i>Crepis</i>, <i>Erigeron</i>, <i>Gnaphalium</i>, <i>Lactuca</i>, <i>Sonchus</i>), <i>Athyriaceae</i> (<i>Athyrium</i>, <i>Diplazium</i>), <i>Berberidaceae</i> (<i>Mahonia</i>), <i>Betulaceae</i> (<i>Carpinus</i>), <i>Boraginaceae</i> (<i>Cynoglossum</i>), <i>Brassicaceae</i> (<i>Rorippa</i>), <i>Buddlejaceae</i> (<i>Buddleja</i>), <i>Caprifoliaceae</i> (<i>Viburnum</i>), <i>Celastraceae</i> (<i>Celastrus</i>, <i>Euonymus</i>), <i>Chloranthaceae</i> (<i>Chloranthus</i>), <i>Cyperaceae</i> (<i>Carex</i>, <i>Eleocharis</i>), <i>Elaeagnaceae</i> (<i>Elaeagnus</i>),</p>	<p><i>Ericaceae</i> (<i>Enkianthus</i>, <i>Gaultheria</i>, <i>Lyonia</i>, <i>Rhododendron</i>, <i>Vaccinium</i>), <i>Gentianaceae</i> (<i>Gentiana</i>), <i>Hypericaceae</i> (<i>Hypericum</i>), <i>Juncaceae</i> (<i>Juncus</i>), <i>Liliaceae</i> (<i>Disporum</i>), <i>Orchidaceae</i> (<i>Amitostigma</i>, <i>Platanthera</i>), <i>Plantaginaceae</i> (<i>Plantago</i>), <i>Poaceae</i> (<i>Digitaria</i>, <i>Eragrostis</i>, <i>Paspalum</i>, <i>Setaria</i>), <i>Polygonaceae</i> (<i>Polygonum</i>, <i>Rumex</i>), <i>Primulaceae</i> (<i>Lysimachia</i>), <i>Ranunculaceae</i> (<i>Anemone</i>, <i>Ranunculus</i>), <i>Rhamnaceae</i> (<i>Rhamnus</i>), <i>Rosaceae</i> (<i>Eriobotrya</i>, <i>Photinia</i>, <i>Prunus</i>, <i>Sorbus</i>), <i>Rubiaceae</i> (<i>Galium</i>), <i>Salicaceae</i> (<i>Salix</i>), <i>Schisandraceae</i> (<i>Kadsura</i>), <i>Valerianaceae</i> (<i>Valeriana</i>), <i>Violaceae</i> (<i>Viola</i>).</p>
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The flora of the South Annamese Province includes numerous endemic derivatives of the thermophilous Hindustan and Malesian flora more typical of the surrounding areas of the southern lowlands of the Indochinese Peninsula. Florogenetically many endemic species of the South Annamese floristic province belong to this group. Among autochthonous endemics of the highest rank within the area should be mentioned the monotypic genus *Indosinia* (*Ochnaceae*) and a very isolated species, *Pinus krempfii*. This pine is sometimes regarded as a member of the separate monotypic coniferous genus *Ducampopinus*. Approximately 23.1% of known Vietnamese endemics occur in the South Annamese floristic province and about 9.9% of endemic Vietnamese species are local endemics of this area (Fig. 4). Endemic species of the area for selected families are listed below:

- Anacardiaceae* (*Gluta compacta*,
G. megalocarpa, *Mangifera reba*,
Semecarpus caudata),
Anisophylleaceae (*Anisophyllea*
penninervata),
Annonaceae (*Drepananthus filiformis*,
Fissistigma poilanei, *Goniothalamus*
ninhianus),
Araceae (*Aglaonema furmeum*,
Cryptocoryne annamica,
Pseudodracontium laoticum),
Araliaceae (*Macropanax schmidii*,
Schefflera buxifolioides, *Sch.*
corymbiformis, *Sch. dongnaiensis*,
Sch. lenticellata, *Sch. nhatrangensis*,
Sch. tribracteolata),
Bignoniaceae (*Stereospermum annamense*),
Euphorbiaceae (*Breynia subindochinensis*,
Croton alpinus, *C. bidopensis*,
C. dalatensis, *C. lamdongensis*,
C. longipes, *C. murex*, *C. scopuligenus*,
C. thoi),
Fabaceae (*Bauhinia involucrans*,
C. splendens, *Dunbaria flavescens*,
D. lecomtei, *Ormosia poilanei*, *Saraca*
schmidiana, *Smithia finetii*),
Flacourtiaceae (*Casearia annamensis*),
Hamamelidaceae (*Distylium annamicum*),
Myrsinaceae (*Ardisia evrardii*, *A. mirabilis*),
Ochnaceae (*Indosinia involucrata*),
Pandanaceae (*Freycinetia webbiana*,
Pandanus multidrupaceus),
Pentaphragmataceae (*Pentaphragma*
gamopetalum, *P. honbaense*),
Pinaceae (*Pinus krempfii*),
Podostemaceae (*Cladopus fallax*,
Diplobryum minutale),
Rosaceae (*Eriobotrya poilanei*, *Rhaphiolepis*
brevipetiolata, *Rubus annamensis*,
R. palmatifolius),
Sabiaceae (*Meliosma donnaiensis*, *M. nana*,
M. simang),
Sapotaceae (*Madhuca alpina*, *Xantolis*
baranensis),
Saxifragaceae (*Polyosma annamensis*,
P. nhatrangensis, *P. turfosa*),
Scrophulariaceae (*Lindernia pierreana*,
Schizotorenia finetiana),
Smilacaceae (*Smilax poilanei*),
Symplocaceae (*Symplocos annamensis*,
S. guillauminii),
Theaceae (*Adinandra microcarpa*,
A. poilanei, *Anneslea dongnaiensis*,
Camellia langbianensis, *C. nervosa*,
Gordonia bidoupenis).

Approximately 502 orchid species from 112 genera are presently known from the South Annamese Province. Among them 58 species are local endemics of this area (Table 8).

Table 8. Orchid species reported from the South Annamese floristic province (local endemics of this area in bold)

<i>Acampe bidoupense</i> ,	<i>Acriopsis indica</i> ,	<i>A. odorata</i> ,
<i>A. papillosa</i> ,	<i>A. liliifolia</i> ,	<i>A. rubescens</i> ,
<i>A. rigida</i> ,	<i>Adenoncos vesiculosa</i> ,	<i>Agrostophyllum callosum</i> ,
<i>Acanthephippium gougahense</i> ,	<i>Aerides falcata</i> ,	<i>A. planicaule</i> ,
<i>A. simplex</i> ,	<i>A. houlettiana</i> ,	<i>Amitostigma bidoupense</i> ,
<i>A. striatum</i> ,	<i>A. multiflora</i> ,	<i>Anoectochilus lylei</i> ,

- Anthogonium gracile*,
Aphyllorchis evrardii,
Apostasia nuda,
A. odorata,
Appendicula gracilis,
A. cornuta,
A. hexandra,
A. reflexa,
Arachnis annamensis,
A. labrosa,
Arundina chinensis,
A. graminifolia,
Ascocentrum garayi,
Ascolabium pusillum,
Biermannia sigaldii,
Brachycorythis galeandra,
Brachypeza laotica,
Bromheadia tenuis,
Bulbophyllum abbrevilabium,
B. andersonii,
B. apodum,
B. astelidum,
B. boulbetii,
B. clandestinum,
B. concinnum,
B. corallinum,
B. crassiusculifolium,
B. elatum,
B. evrardii,
B. farreri,
B. fibratum,
B. flabellovenaris,
B. frostii,
B. hirtum,
B. hymenanthum,
B. ignevenosum,
B. insulsum,
B. kanburiense,
B. khasyanum,
B. lemniscatoides,
B. longiflorum,
B. luanii,
B. mastersianum,
B. monanthum,
B. moniliforme,
B. nigrescens,
B. odoratissimum,
B. oreogenes,
B. pecten-veneris,
B. picturatum,
B. pinicolum,
B. poilanei,
B. protractum,
B. psittacoglossum,
B. pumilio,
B. refractum,
B. reptans,
B. retusiusculum,
B. rufinum,
B. secundum,
B. semiteritifolium,
B. sigaldiae,
B. simondii,
B. spadiceiflorum,
B. spathulatum,
B. stenobulbon,
B. subebulbum,
B. tixieri,
B. tortuosum,
B. umbellatum,
B. vietnamense,
Calanthe alleizettei,
C. alismifolia,
C. angusta,
C. angustifolia,
C. cardioglossa,
C. clavata,
C. lyroglossa,
C. masuca,
C. pachystalix,
C. puberula,
C. succedanea,
C. sylvatica,
C. triplicata,
C. velutina,
Callostylis rigida,
Cephalantheropsis longipes,
C. obcordata,
Ceratostylis evrardii,
C. radiata,
C. siamensis,
C. subulata,
Cheirostylis cochinchinensis,
Chiloschista exuperei,
C. parishii,
Chrysoglossum ornatum,
Cleisocentron klossii,
Cleisomeria lanatum,
Cleisostoma arietinum,
C. birmanicum,
C. crochetii,
C. duplicilobum,
C. filiforme,
C. fuerstenbergianum,
C. inflatum,
C. racemiferum,
C. striatum,
C. williamsonii,
Coelogyne assamica,
C. brachyptera,
C. brunnea,
C. calcicola,
C. eberhardtii,
C. filipeda,
C. fimbriata,
C. lactea,
C. lawrenceana,
C. lentiginosa,
C. mooreana,
C. nitida,
C. ovalis,
C. pallens,
C. sanderae,
C. stricta,
C. tenasserimensis,
C. trinervis,
C. viscosa,
Collabium chloranthum,
Cryptostylis arachnites,
Cymbidium aloifolium,
C. cyperifolium,
C. dayanum,
C. devonianum,
C. eburneum,
C. ensifolium,
C. erythrostylum,
C. hookerianum,
C. insigne,
C. iridioides,
C. lancifolium,
C. lowianum,
C. sanderae,
C. schroederi,
C. sinense,
Dendrobium aduncum,
D. aloifolium,
D. anceps,
D. annamense,
D. anosmum,
D. aphyllum,
D. aqueum,
D. bellatulum,
D. bilobulatum,

- D. capillipes*,
D. cariniferum,
D. caryaecolum,
D. christyanum,
D. chrysotoxum,
D. concinnum,
D. crepidatum,
D. cruentum,
D. crumenatum,
D. crystallinum,
D. cumulatum,
D. dalatense,
D. dantaniense,
D. delacourii,
D. dentatum,
D. draconis,
D. ellipsophyllum,
D. exile,
D. farmeri,
D. fimbriatum,
D. formosum,
D. gratiosissimum,
D. harveyanum,
D. hemimelanoglossum,
D. hendersonii,
D. hercoglossum,
D. heterocarpum,
D. hymenanthum,
D. infundibulum,
D. intricatum,
D. khanhoaense,
D. langbianense,
D. leonis,
D. lindleyi,
D. linguella,
D. lobbii,
D. lomatochilum,
D. mannii,
D. moschatum,
D. nathanielis,
D. nobile,
D. oligophyllum,
D. pachyglossum,
D. pachyphyllum,
D. palpebrae,
D. parciflorum,
D. parcum,
D. parishii,
D. perulatum,
D. podagraria,
D. porphyrophyllum,
D. primulinum,
D. pseudointricatum,
D. pseudotenellum,
D. salaccense,
D. secundum,
D. signatum,
D. sociale,
D. stuartii,
D. terminale,
D. thyrsiflorum,
D. tortile,
D. truncatum,
D. uniflorum,
D. venustum,
D. virgineum,
D. wattii,
D. williamsonii,
Didimoplexiopsis
khiriwongensis,
Didimoplexis pallens,
Diglyphosa evrardii,
Dipodium paludosum,
Doritis pulcherrima,
D. regnieriana,
Epigeneium amplum,
E. annamense,
E. cacuminis,
E. chapaense,
Epipogium roseum,
Eria acervata,
E. amica,
E. apertiflora,
E. bidupensis,
E. biflora,
E. bipunctata,
E. bractescens,
E. clausa,
E. clavicaulis,
E. cochinchinensis,
E. corneri,
E. coronaria,
E. dacrydium,
E. donnaiensis,
E. eriopsidobulbon,
E. floribunda,
E. gagnepainii,
E. globifera,
E. globulifera,
E. lactiflora,
E. lasiopetala,
E. longipes,
E. muscicola,
E. oblitterata,
E. obscura,
E. paniculata,
E. pannea,
E. pulverulenta,
E. pusilla,
E. siamensis,
E. sutepensis,
E. thao,
E. tomentosa,
E. truncata,
Eriodes barbata,
Eulophia graminea,
E. spectabilis,
E. yunnanensis,
Flickingeria albopurpurea,
F. angustifolia,
F. fimbriata,
F. ritaeana,
F. stenoglossa,
F. vietnamensis,
Gastrochilus calceolaris,
G. intermedius,
G. obliquus,
Geodorum recurvum,
Goodyera foliosa,
G. fumata,
G. procera,
G. schlechtendaliana,
Habenaria acuífera,
H. apetala,
H. commelinifolia,
H. dentata,
H. falcatopetala,
H. limprichtii,
H. lucida,
H. malintana,
H. mandersii,
H. poilanei,
H. reniformis,
H. rhodocheila,
H. rumphii,
Herminium lanceum,
Herpysma longicaulis,
Hetaeria oblongifolia,
Holcoglossum amesianum,
H. subulifolium,
Hygrochilus parishii,
Kingidium deliciosum,
Liparis acuminata,

- L. atrosanguinea*,
L. bootanensis,
L. campylostalix,
L. cespitosa,
L. chapaënsis,
L. compressa,
L. dendrochiloides,
L. distans,
L. gibbosa,
L. luteola,
L. mannii,
L. mantidopsis,
L. nana,
L. nervosa,
L. nigra,
L. paradoxa,
L. piriformis,
L. regnieri,
L. rheedii,
L. viridiflora,
Listera latilabra,
Ludisia discolor,
Luisia curtisii,
L. macrotis,
L. morsei,
L. platyglossa,
L. psyche,
L. zollingeri,
Macodes cupida,
Malaxis acuminata,
M. finetii,
M. ophridis,
M. octodentata,
M. orbicularis,
M. purpurea,
M. tixieri,
Micropera thailandica,
Monomeria dichroma,
Nervilia crocififormis,
Oberonia acarus,
O. caulescens,
O. dalatensis,
O. ensiformis,
O. evrardii,
O. falcata,
O. integerrima,
O. langbianensis,
O. lycopodioides,
O. pachyphylla,
O. rosea,
O. rufilabris,
O. tixieri,
O. trochopetala,
O. variabilis,
Odontochilus poilanei,
Ornithochilus difformis,
Otochilus albus,
O. fuscus,
O. pseudoporrectus,
Pachystoma pubescens,
Panisea albiflora,
P. apiculata,
P. tricallosa,
P. uniflora,
Paphiopedilum appletonianum,
P. callosum,
P. delenatii,
P. villosum,
Papilionanthe pedunculata,
P. teres,
Pecteilis henryi,
P. susannae,
Pelatantheria ctenoglossum,
Peristylus aristatus,
P. calcaratus,
P. candidus,
P. constrictus,
P. densus,
P. goodyeroides,
P. holttumianus,
P. parishii,
Phaius flavus,
P. longicornu,
P. mishmensis,
P. tankervilleae,
Phalaenopsis chibae,
P. cornu-cervi,
P. gibbosa,
P. mannii,
P. parishii,
Pholidota articulata,
P. chinensis,
P. convallariae,
P. guibertiae,
P. imbricata,
P. leveilleana,
P. pachyglossa,
P. pallida,
P. recurva,
P. rubra,
Phreatia densiflora,
P. formosana,
P. laxiflora,
P. plantaginifolia,
Platanthera angustata,
Plocoglottis bokorensis,
Podochilus microphyllus,
Polystachya concreta,
Pomatocalpa falciformis,
P. grandis,
P. tonkinensis,
Pristiglottis saprophytica,
Pteroceras leopardinum,
P. semiteretifolium,
P. teres,
Renanthera annamensis,
R. coccinea,
R. imschootiana,
Rhomboda tokioi,
Rhynchogyna fallax,
Rhynchostylis coelestis,
R. gigantea,
Sarcoglyphis mirabilis,
Schoenorchis eberhardtii,
S. gemmata,
S. micrantha,
S. aurea,
S. eburnea,
S. rosea,
S. tixieri,
Smitinandia micrantha,
Spathoglottis affinis,
S. plicata,
S. pubescens,
Spiranthes sinensis,
Staurochilus fasciatus,
Stereochilus dalatensis,
Sunipia andersonii,
S. annamensis,
S. pallida,
S. scariosa,
Taeniophyllum glandulosum,
T. minimum,
T. obtusum,
Tainia angustifolia,
T. hookeriana,
T. latifolia,
T. viridifusca,
Thelasis pygmaea,
Thrixspermum amplexicaule,
T. ancoriferum,
T. annamense,
T. centipeda,

<i>T. fragrans</i> ,	<i>T. seidenfadenii</i> ,	<i>V. concolor</i> ,
<i>T. leucarachne</i> ,	<i>T. triflora</i> ,	<i>V. denisoniana</i> ,
<i>T. merguense</i> ,	<i>Trichotisia dalatensis</i> ,	<i>V. lilacina</i> ,
<i>T. pusillum</i> ,	<i>T. dasyphylla</i> ,	<i>V. pumila</i> ,
<i>T. trichoglottis</i> ,	<i>T. microphylla</i> ,	<i>Vanilla annamica</i> ,
<i>Thunia alba</i> ,	<i>T. pulvinata</i> ,	<i>V. aphylla</i> ,
<i>Trias nasuta</i> ,	<i>T. velutina</i> ,	<i>Zeuxine parvifolia</i> ,
<i>Trichoglottis lanceolaria</i> ,	<i>Uncifera dalatensis</i> ,	<i>Z. strateumatica</i> .
<i>T. retusa</i> ,	<i>Vanda bidupensis</i> ,	

The well known slipper orchid, *Paphiopedilum delenatii*, that is of outstanding significance in horticulture, hybridizing and improvement selection is a strict local endemic of the South Annamese floristic province. Regrettably this species, which inhabits only a very small area on the eastern slopes of mountain systems along northeastern margin of the province, has become extremely rare due to commercial overcollecting.

7.6. South Indochinese Province

The boundaries of this province were preliminarily outlined by Takhtajan (1986). The natural range of the South Indochinese floristic province primarily includes wide lowland and rolling hill areas of southern Vietnam and Cambodia. This area is delimited in the southern part of Vietnam by the lowland districts of the Mekong River delta, coastal plains and terraces, the Cho Reo Depression, and low plateaux with elevations up to 500 m a.s.l. In Vietnam the lowland areas of the following administrative provinces are within this floristic province: Gia Lai, Phu Yen, Dac Lac, Khanh Hoa, Ninh Thuan, Binh Phuoc, Dong Nai, Binh Thuan, Ba Ria – Vungtau, Ho Chi Minh (Saigon) city, Tay Ninh, Long An, Dong Thap, Tien Giang, An Giang, Kien Giang, Cam Tho, Vinh Long, Ben Tre, Tra Vinh, Soc Trang, Bac Lieu and Ca Mau (Fig. 3). The western and northern borders of the South Indochinese floristic province are not well defined. Reasonably the area of the province includes all Cambodia. The floristic province is bordered on the northwest by the east west oriented low sandstone Chuor Phnum Dangrek Range and the extreme northwestern limb of the Kravanh (Cardamom) Mountains along the Thai-Cambodian border. The northern limit of the province includes the southern part of Laos (Cham Pasak and lowland portions of Attapu Province) and the eastern part of Thailand with the lowland valleys of the Mekong River basin.

The largest area of the South Indochinese Province is lowland plain lying on a solid crystalline platform of Precambrian age. This basement platform has not experienced as considerable uplifts as have other regions and now appears as a number of high plateaux in central part of southern Vietnam. Before steady Mesozoic erosion of ancient mountain formations in Indochina, these low areas of lowland flat plains and rolling terrain were covered by considerable deposits of more or less highly metamorphosed alluvium, continental and marine sediments such as clayey or quartzitic sandstones, slate or schist. Scattered flat-topped sandstone hills and rounded hills of andesite or basalt now break this terrain. Quaternary alluvial deposits also cover broad areas of the province. A prominent Pleistocene marine terrace belonging to the South Indochinese floristic province extends discontinuously along the coastline for nearly 100 km near Phan Rang in southeastern Vietnam. Holocene beach sands are the most common substrate in these areas. Holocene deposits of continental origin also cover extensive areas in central Cambodia and in the Mekong River basin.

Many areas of the province are covered with basalt flows of late Tertiary and Quaternary age. The largest of them are the relatively low Rattanakiri and Chhlong Plateaux that lie in northeast Cambodia and form a transition to the Truong Son Range. The basaltic soils in the area are most weathered and deepest to the south and shallower to the north, but are always relatively deep and rich. Scattered granite outcrops and small eroded volcanic cones are also observed in many places of the area (Rundel 1999).

The southwestern margin of the lowland part of the South Indochinese floristic province is formed by Chuor Phnum Kravanh (Cardamom) and Chuor Phnom Damrei (Elephant) Mountains with peaks reaching 1500–1600 m a.s.l. and to 1813 m in the isolated granite mountain block of Phnom Aoral, the highest elevation of the area. These ranges are mainly composed of Mesozoic sandstone, with localized areas of limestone and volcanic magmatic rock (Rundel 1999).

A monsoon sub-equatorial climate with summer rains is typical of most areas of the South Indochinese floristic province. Southwest monsoon winds from mid-April or May through October bring moist air masses from the Gulf of Thailand and heavy rains. The continental monsoon winds from the northeast bring dry conditions between November and March. In coastal areas on the east side of the province peak rainfall is shifted to autumn and the first part of winter (Fig. 1).

Lowland plains within the province normally receive 1500–2000 mm of rainfall annually. The central portion around the basin of Tonle Sap Lake annually receives between 1292 to 1403 mm (Crocker 1962). The driest areas of the South Indochinese floristic province territory are narrow lowland coastal plains of southern Vietnam in Khanh Hoa, Ninh Thuan and Binh Thuan administrative provinces (Fig. 2). These areas receive minimum amounts of annual precipitation for South-East Asia, varying between 409 and 757 mm (Bruzon & Carton 1930; Schzeglova 1957; Schmid 1974). The dry season in these semi-arid areas lasts from 8 to 10 months with a single rainy season in October–December. The climate of this area is characterized as a monsoon tropical climate with warm winter and autumn–winter rains (Nguyen Khanh Van *et al.* 2000).

Annual rainfall increases considerably in areas adjoining the coast of the Gulf of Thailand especially on the southwest-facing slopes of the Cardamom and Elephant Mountains. These regions receive from 3000 to 5000 mm of precipitation annually (Khuong Bun Luk 1971; Tixier 1979). This area is one of the wettest regions in South-East Asia with recorded maximum annual precipitation of 5300 mm (Rundel 1999). The dry season here is restricted to 2–3 months from December through February.

In general mean monthly temperatures in lowland areas of the South Indochinese floristic province vary between 25 and 32° C throughout the year. However, in continental northeastern regions and in high coastal mountains winter temperatures may be much lower. Minimum temperatures reported from these areas are 5.7° C on the Playcu Plateau at 800 m a.s.l. of Gia Lai Province of Vietnam (Nguyen Khanh Van *et al.* 2000) and 11.4° C in the Chuor Phnom Damrei (Elephant) Mountains in Cambodia (Lay Khim & Taylor-Hunter 1995). January is the coolest month in these areas.

Deciduous and semi-deciduous forests are the main vegetation types in the South Indochinese floristic province. These forests cover a larger area in mainland South-East Asia than any other forest type, extending from northeastern India and Myanma through Thailand to the Mekong River region of Laos and the lowlands of Cambodia and southern Vietnam (Rundel 1999). Deciduous forests and savanna-like woodlands together with semi-deciduous forest communities form the general picture of the vegetation of the floristic region. Deciduous species of *Dipterocarpaceae* are the regular dominant element in these communities including the most common *Shorea siamensis*, *S. obtusa*, *Dipterocarpus obtusifolius* and *D. tuberculatus*. A remarkable diversity of other small trees, including *Pinus merkusii*, are also occasional codominants.

Dry deciduous forests exhibit relatively moderate species richness and a similar basic floristic structure. These forests may also support considerable specific local features and include numerous endemic species. This vegetation type is widely distributed across mainland South-East Asia. Fire is a natural frequent event in most deciduous forests dominated by taxa in the *Dipterocarpaceae* and many species in these forests exhibit a variety of adaptations to burning.

Semi-deciduous or semi-evergreen forests are transitional types of vegetation, formed in areas connecting regions of lowland evergreen and deciduous forest formations. These forests have a wide distribution across the South Indochinese floristic province and include a variety of different community types. The canopy species composition can vary here from being primarily evergreen to one in which deciduous species dominate. The distribution of semi-evergreen forest is largely

determined by climatic factors and may form over a variety of substrates in southern Vietnam. Habitats here have moderate annual rainfall of about 1200–2000 (2500) mm and 3–6 months of drought (Rundel 1999). Many of the large trees are deciduous in this community, with leaf fall reaching its peak in February. The trees in the understory are largely evergreen.

Deep "*terres rouges*" soils formed above basaltic parent materials in the Vietnamese part of the South Indochinese floristic province support diverse semi-deciduous forests with an upper canopy reaching 40–50 m. Similar but usually drier forests occur here on skeletal basaltic soils, referred to in the French literature as "*terres brunes*". Dense semi-deciduous forest also occurs in the area on deep alluvial soils formed from schistic and granitic parent material (Schmid 1974). The most usual dominant canopy tree species in this community are:

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|--|--|
| <i>Anacardiaceae</i> (<i>Dracontomelum duperreanum</i> , <i>Swintonia griffithii</i>), | <i>Lauraceae</i> (<i>Cinnamomum</i> spp., <i>Litsea</i> spp., <i>Phoebe</i> sp.), |
| <i>Apocynaceae</i> (<i>Alstonia</i> spp., <i>Wrightia</i> spp.), | <i>Lythraceae</i> (<i>Lagerstroemia angustifolia</i> , <i>L. calyculata</i> , <i>L. floribunda</i>), |
| <i>Bignoniaceae</i> (<i>Stereospermum</i> sp.), | <i>Meliaceae</i> (<i>Aglaia</i> sp., <i>Amoora gigantea</i> , <i>Dysoxylum</i> sp., <i>Sandoricum indicum</i> , <i>Toona ferifuga</i>), |
| <i>Chrysobalanaceae</i> (<i>Parinari annamense</i>), | <i>Moraceae</i> (<i>Artocarpus</i> sp., <i>Ficus</i> spp.), |
| <i>Clusiaceae</i> (<i>Cratoxylum formosum</i>), | <i>Myrtaceae</i> (<i>Eugenia</i> sp., <i>Syzygium zeylandicum</i>), |
| <i>Combretaceae</i> (<i>Anogeissus acuminata</i> , <i>A. vulgaris</i> , <i>Terminalia bellirica</i> , <i>T. calamansanai</i> , <i>T. chebula</i> , <i>T. nigrovenulosa</i>), | <i>Rubiaceae</i> (<i>Adina cordifolia</i>), |
| <i>Datisceaeae</i> (<i>Tetrameles nudiflora</i>), | <i>Sapindaceae</i> (<i>Pometia pinnata</i> , <i>Schleichera oleosa</i>), |
| <i>Dipterocarpaceae</i> (<i>Anisoptera costata</i> , <i>Dipterocarpus alatus</i> , <i>D. costatus</i> , <i>D. dyeri</i> , <i>D. intricatus</i> , <i>D. turbinatus</i> , <i>Hopea odorata</i> , <i>Shorea guiso</i> , <i>S. hypochra</i> , <i>Shorea roxburghii</i> , <i>S. vulgaris</i> , <i>Vatica</i> sp.), | <i>Sapotaceae</i> (<i>Palaquium obovatum</i>), |
| <i>Ebenaceae</i> (<i>Diospyros</i> spp.), | <i>Simaroubaceae</i> (<i>Irvingia malayana</i> , <i>I. oliveri</i>), |
| <i>Fabaceae</i> (<i>Afzelia xylocarpa</i> , <i>Cassia siamea</i> , <i>Peltophorum dasyrachis</i> , <i>Pterocarpus macrocarpus</i> , <i>Sindora siamensis</i>), | <i>Sterculiaceae</i> (<i>Heritiera javanica</i> , <i>Pterospermum diversifolium</i> , <i>P. megalocarpum</i> , <i>Sterculia hypochra</i>), |
| | <i>Ulmaceae</i> (<i>Celtis sinensis</i> , <i>Holoptelea integrifolia</i>), |
| | <i>Verbenaceae</i> (<i>Vitex pubescens</i>). |

The subcanopy of tree species composition in these forests is rich and includes:

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|--|---|
| <i>Annonaceae</i> (<i>Miliusa velutina</i> , <i>Polyalthia evecta</i> , <i>P. jucunda</i>), | <i>Lythraceae</i> (<i>Lagerstroemia flos-reginae</i>), |
| <i>Araliaceae</i> (<i>Macropanax concinnum</i>), | <i>Myristicaceae</i> (<i>Knema linifolia</i>), |
| <i>Arecaceae</i> (<i>Licuala</i> sp.), | <i>Myrtaceae</i> (<i>Eugenia</i> sp.), |
| <i>Ebenaceae</i> (<i>Diospyros nitida</i>), | <i>Sapindaceae</i> (<i>Harpullia arborea</i> , <i>Mischocarpus</i> sp., <i>Xerospermum laoticum</i>), |
| <i>Euphorbiaceae</i> (<i>Baccaurea oxycarpa</i> , <i>Cleistanthus</i> sp., <i>Coelodiscus</i> sp., <i>Excoecaria oppositifolia</i> , <i>Gelonium multiflorum</i> , <i>Macaranga henricorum</i>), | <i>Symplocaceae</i> (<i>Symplocos longifolia</i>), |
| <i>Icacinaceae</i> (<i>Gomphandra</i> sp.), | <i>Tiliaceae</i> (<i>Brownlowia</i> spp.), |
| | <i>Ulmaceae</i> (<i>Gironniera subaequalis</i>), |
| | <i>Urticaceae</i> (<i>Laportea</i> sp.). |

Lianas and epiphytes are very common in semi-deciduous forest. They reach their maximum abundance and diversity in gallery forests formed as a riverine modification of semi-deciduous woods. Main tree dominants here may reach 30–35 m. Most common among them are species of *Moraceae* (*Ficus* spp.), *Fabaceae* (*Afzelia xylocarpa*, *Pterocarpus macrocarpus*, *Sindora siamensis*), *Lythraceae* (*Lagerstroemia calyculata*, *L. angustifolia*) and *Datisceaeae* (*Tetrameles nudiflora*). Tall, dense clumps of bamboo (commonly *Bambusa arundinacea* and *B. beecheyi*) and

species of *Pandanus* often form dense thickets along rivers. Large grasses and herbs from the *Araceae*, *Marantaceae* and *Zingiberaceae* usually are also common here.

Deciduous forests and savanna-like woodlands are the most typical and widespread types of vegetation within the South Indochinese floristic province. Commonly these habitats receive less than 1800 mm of annual rainfall with a 5–7 month dry period. These forests form over a variety of substrates, but are most widespread on young basalts and on shallow granitic soils. Dominant species of deciduous forests and woodlands are species of *Dipterocarpaceae* that are widespread in semiarid areas of mainland South-East Asia. These forests support important local endemism among different groups of plants.

Dry deciduous forests and woodlands on basalt occupy hydromorphic soils that are thin to moderate in depth and low in nutrients. These soils have been termed "*terres grises*". Poor drainage leads to anaerobic soil conditions that are typical of these soils. Laterites, which impede root penetration, are common here. While most of this community in Vietnam occurs over basalts, deciduous Dipterocarp forest is not restricted to this substrate and extends continuously into Cambodia on granitic basement soils (Rundel 1999).

The canopy structure of deciduous forests is open with scattered trees and shrubs in a matrix of grassy understory. The height of the dominant canopy trees is highly irregular, varying from 10 m to 20 (25) m for individual trees. Liana and epiphyte diversity and abundance are rather low. Most common among them are species of large ferns (*Drynaria*, *Platynerium*, *Polypodium*) and orchids. Small succulent epiphytic vines, such as *Dischidia* and *Hoya* (*Asclepiadaceae*) are also common. The diversity of herbaceous perennials is relatively high and many of them are typical geophytes, developing from underground tubers or bulbs. The grass understory frequently reaches a height 1–1.5 m. Most important species here are *Imperata cylindrica*, *Heteropogon contortus*, *Themeda triandra*, *Alloteropsis semialata* and some species of bamboo.

Relatively few tree species are dominant in dry deciduous forests. Often they represent only the following four families:

<i>Combretaceae</i> (<i>Terminalia alata</i> , <i>T. chebula</i> , <i>T. corticosa</i>),	<i>D. tuberculatus</i> , <i>Shorea obtusa</i> , <i>Sh. siamensis</i>),
<i>Dipterocarpaceae</i> (<i>Dipterocarpus</i> <i>intricatus</i> , <i>D. obtusifolius</i> ,	<i>Fagaceae</i> (<i>Lithocarpus lindleyana</i> , <i>Quercus kerrii</i>),
	<i>Fabaceae</i> (<i>Pterocarpus macrocarpus</i>).

A large number of other woody species occur in the understory strata of deciduous forests. Most common of them belong to the following families:

<i>Anacardiaceae</i> (<i>Buchanania reticulata</i> , <i>Lannea wodier</i> , <i>Mangifera</i> sp., <i>Semecarpus reticulata</i>),	<i>Dipterocarpaceae</i> (<i>Shorea roxburghii</i>),
<i>Arecaceae</i> (<i>Corypha lecomtei</i>),	<i>Ebenaceae</i> (<i>Diospyros ehretioides</i>),
<i>Bignoniaceae</i> (<i>Stereospermum chelonoides</i>),	<i>Euphorbiaceae</i> (<i>Aporosa sphaerosperma</i> , <i>Glochidion fagifolium</i> , <i>G. obliquum</i> , <i>Phyllanthus emblica</i>),
<i>Bombacaceae</i> (<i>Bombax anceps</i>),	<i>Fabaceae</i> (<i>Albizzia lebeekoides</i> , <i>A. procera</i> , <i>Bauhinia variegata</i> , <i>Dalbergia</i> <i>nigrescens</i> , <i>D. oliveri</i> , <i>Sindora siamensis</i> , <i>Pterocarpus macrocarpus</i> , <i>Xylia</i> <i>xylocarpa</i>),
<i>Burseraceae</i> (<i>Canarium subulatum</i>),	<i>Lecythidaceae</i> (<i>Careya sphaerica</i>),
<i>Capparaceae</i> (<i>Capparis thorelii</i>),	<i>Loganiaceae</i> (<i>Strychnos nux-blanda</i>),
<i>Caprifoliaceae</i> (<i>Viburnum punctatum</i>),	<i>Lythraceae</i> (<i>Lagerstroemia</i> spp.),
<i>Celastraceae</i> (<i>Solenospermum wallichii</i>),	<i>Melastomataceae</i> (<i>Memecylon edule</i> , <i>M. laevigatum</i>),
<i>Chrysobalanaceae</i> (<i>Parinari annamense</i>),	<i>Meliaceae</i> (<i>Azadirachta indica</i>),
<i>Clusiaceae</i> (<i>Cratoxylum formosum</i>),	
<i>Combretaceae</i> (<i>Terminalia alata</i>),	
<i>Cycadaceae</i> (<i>Cycas siamensis</i>),	
<i>Simaroubaceae</i> (<i>Irvingia malayana</i>),	
<i>Dilleniaceae</i> (<i>Dillenia pentagyna</i>),	

Myrtaceae (*Eugenia jambolana*, *Tristania burmanica*),
Oleaceae (*Schrebera swietenoides*),
Poaceae (*Bambusa arundinacea*),
Rhamnaceae (*Zizyphus rugosa*),
Rubiaceae (*Adina cordifolia*, *A. sessilifolia*,
Gardenia erythroclada, *G. obtusifolia*,
G. philastreii, *Hymenodictyon excelsum*,
Ixora cuneifolia, *Morinda citrifolia*,
Paradina hirsuta, *Randia tomentosa*,
R. uliginosa, *Wendlandia glabrata*),
Sapindaceae (*Erioglossum rubiginosum*),
Sterculiaceae (*Eriolaena candollei*),
Symplocaceae (*Symplocos* spp.),
Tiliaceae (*Grewia asiatica*, *Grewia paniculata*),
Verbenaceae (*Gmelina hystrix*, *Premna cambodiana*, *Vitex* spp.).

Pinus merkusii usually becomes dominant in dry lowland forests on thin well-drained basaltic soils. Occasionally this heliophilous species appears as monodominant in open stands or woodlands with scattered shrubby and grassy associates. However, most often pine forests have a number of associated broad-leaved deciduous tree species (Dy Phon 1970; Schmid 1974). Frequent associates in dry pine forests are:

Anacardiaceae (*Mangifera* sp.,
Melanorrhoea laccifera),
Chrysobalanaceae (*Parinari annamensis*),
Combretaceae (*Terminalia chebula*),
Crypteroniaceae (*Crypteronia paniculata*),
Dipterocarpaceae (*Dipterocarpus obtusifolius*, *D. intricatus*,
D. tuberculatus, *Vatica cinerea*),
Ericaceae (*Vaccinium chevalieri*),
Fagaceae (*Lithocarpus harmandii*,
Lithocarpus dealbata, *Quercus helferiana*),
Lecythidaceae (*Careya arborea*),
Magnoliaceae (*Michelia baillonii*),
Rubiaceae (*Mitragyna hirsuta*),
Sapotaceae (*Xantolis cambodiana*),
Theaceae (*Schima crenata*).

The lower woody stratum includes many species the majority of which are evergreen (Dy Phon 1970). Among them are:

Dilleniaceae (*Dillenia ovata*, *D. pentagyna*),
Euphorbiaceae (*Aporosa ficifolia*,
A. sphaerosperma, *Mallotus cochinchinensis*, *Phyllanthus emblica*),
Ericaceae (*Craibiodendron stellatum*,
Vaccinium bracteatum),
Fabaceae (*Pithecellobium lucidum*),
Fagaceae (*Lithocarpus cambodiensis*,
L. eucalyptifolia, *L. harmandii*),
Gentianaceae (*Fagraea ceilanica*),
Juglandaceae (*Engelhardia spicata*),
Melastomataceae (*Melastoma sanguineum*,
Memecylon acuminatum, *Pternandra caerulescens*),
Myrtaceae (*Decaspermum fruticosum*,
Tristania burmanica),
Rubiaceae (*Gaertnera sralensis*, *Randia tomentosa*, *Wendlandia cambodiana*,
W. tonkiniana),
Tiliaceae (*Grewia eriocarpa*),
Verbenaceae (*Callicarpa rubella*).

Lianas and epiphytes are not common here. Among epiphytes are various xerophytic ferns such as *Vittaria elongata*, *Asplenium nidus*, *Davallia trichomanoides*, *Humata repens*, *Aglaomorpha coronans*, *Drynaria quercifolia*, *D. rigidula*, *Microsporium* sp., *Platynerium coronarium*, *Polypodium subauriculatus* and *Pyrrosia* sp. Other plants of this group are small epiphytic vines of the genera *Dischidia* and *Hoya* (*Asclepiadaceae*), as well as numerous orchids.

The common grasses on the forest floor are *Amphilophis gleba*, *Andropogon intermedius*, *Exothea abyssinica*, *Hyparrhenia schmidiana*, *Imperata cylindrica*, *Kerriochloa siamensis* and *Polytoca heteroclita* (Schmid 1974; Lay Khim & Taylor-Hunter 1995).

Although *Pinus merkusii* is a lower elevation species and *P. kesiya* is typically a montane species, their ranges frequently overlap in the area. *Pinus kesiya* prefers more mesic conditions and deeper soils, while *P. merkusii* is less demanding of soil moisture, depth and nutrient availability.

As a result these species often separate in their range of overlap more on the basis of edaphic conditions than on elevation (Rundel 1999).

Open dry grasslands and savanna-like woodlands are widely distributed in the South Indochinese floristic province and represent successive stages of anthropogenic degradation of primary deciduous and semi-deciduous forests. A variety of weedy shrubs become aggressive invaders of these habitats under regimes of frequent disturbance. These include bushy shrubs and small trees such as *Clerodendron serratum* (*Verbenaceae*), *Grewia* spp. (*Tiliaceae*), *Lantana camara* (*Verbenaceae*), *Rhodomyrtus* sp. (*Myrtaceae*), *Zizyphus* sp., *Rhamnus* sp. (*Rhamnaceae*) and *Eriolaena* sp. (*Sterculiaceae*).

The flora of the South Indochinese floristic province is very rich but very poorly studied yet. It is mainly composed of Indomalesian and Sino-Indomalesian elements and presents certain affinities with the floras of Malesia. Also within the area are a number of important centres of local endemism, namely Phnom Dangrek, Chuor Phnum Kravanh (Cardamom), Chuor Phnom Damrei (Elephant) Mountains, the Mekong basin and the Tonle Sap floodplain in Cambodia, as well as east coastal territories of the province in Vietnam. Total endemism in the flora of the South Indochinese floristic province is estimated as 5–10% at the species level, and about 26% of all species occurring here are endemic to mainland South-East Asia (Dy Phon 1970, 1982).

Three endemic monotypic genera *Pseudostriga* (*Scrophulariaceae*), *Christensonia* and *Eparmatostigma* (*Orchidaceae*) are known from in the South Indochinese floristic province. About 25.8% of Vietnamese endemics occur in this territory, and about 16.9% of endemic Vietnamese species are local endemics of this area (Fig. 4). Endemic species of selected families are listed below:

Anacardiaceae (*Bouea poilanei*, *Buchanania evrardii*, *Dracontomelum schmidii*, *Mangifera dongnaiensis*, *M. minutifolia*, *Microstemon annamense*, *Swintonia minuta*, *S. pierrei*),

Annonaceae (*Alphonsea philastreana*, *Dasyaschalon evrardii*, *D. lomentaceum*, *D. macrocalyx*, *D. robinsonii*, *Desmos dinhensis*, *Enicosanthum daclacensis*, *Goniothalamus gabriacianus*, *G. gracilipes*, *Miliusa baillonii*, *M. bangoiensis*, *Mitrella mesnyi*, *M. touranensis*, *Mitrephora pallens*, *Polyalthia bracteosa*, *P. debilis*, *P. floribunda*, *P. intermedia*, *P. luensis*, *P. minima*, *P. sessiliflora*, *Popowia cambodiana*, *Pseuduvaria parviflora*, *Uvaria flexuosa*, *U. pierrei*, *U. varaigneana*, *Xylophia pierrei*, *X. poilanei*),

Araceae (*Amorphophallus lanuginosus*, *A. operus*, *A. panomensis*, *A. pilosus*, *A. pusillus*, *A. scaber*, *Arisaema condaoëense*, *A. pierreanum*, *Homalomena cochinchinensis*, *Pseudodracontium fallax*, *P. harmandii*, *Typhonium violaeifolium*),

Araliaceae (*Schefflera canaensis*,

Sch. chevalieri, *Sch. crassibracteata*, *Sch. leroyiana*, *Sch. poilaneana*),

Caryophyllaceae (*Polycarpaea arenaria*, *P. thymoidea*),

Clusiaceae (*Garcinia loureiri*),

Combretaceae (*Terminalia cambodiana*, *T. darfeuillana*),

Connaraceae (*Rourea harmandiana*),

Cucurbitaceae (*Trichosanthes pierrei*),

Cycadaceae (*Cycas inermis*),

Dipterocarpaceae (*Hopea cordata*, *Shorea falcata*),

Ebenaceae (*Diospyros bejaudii*,

D. cambodiana),

Euphorbiaceae (*Actephila albidula*,

A. macrantha, *A. nitidula*, *A. pierrei*,

Alchornea annamica, *Antidesma*

phanrangense, *A. rec*, *Baccaurea henii*,

Blachia poilanei, *Breynia diversifolia*,

Cleistanthus annamensis, *C. concinnus*,

C. pierrei, *Cnesmone peltata*,

C. poilanei, *Coccoceras anisopodum*,

Croton chevalieri, *C. dodecamerus*,

C. dongnaiensis, *C. ignifex*, *C. lasianthus*,

C. limtincola, *C. phuquocensis*,

Dalechampia falcata, *Dimorphocalyx*

poilanei, *Drypetes poilanei*, *D. thorelii*,

Excoecaria poilanei, *Flueggea jullienii*,

- Mallotus hanheoënsis*, *Melanolepis vitifolia*, *Phyllanthus arenarius*, *Ph. banii*, *Ph. daclacensis*, *Ph. evrardii*, *Ph. geoffrayi*, *Ph. insulensis*, *Ph. kampotensis*, *Ph. nhatrangensis*, *Ph. pulchroides*, *Ph. trungii*, *Sauropus poilanei*, *Trigonostemon capitellatus*, *T. cochinchinensis*, *T. fragilis*, *T. harmandii*, *T. hybridus*, *T. pierrei*, *T. poilanei*, *T. rubescens*, *T. sanguineus*, *T. taynguyenensis*),
- Fabaceae** (*Acacia vietnamensis*, *Bauhinia calycina*, *B. godefroyi*, *Caesalpinia nhatrangensis*, *Christia constricta*, *Ch. convallaria*, *Ch. lychnucha*, *Clitoria linearis*, *Crotalaria annamensis*, *Cynometra dongnaiensis*, *Dalbergia dialoides*, *D. thorelii*, *D. vietnamensis*, *Dolichos lygodioides*, *Dysolobium apioides*, *Entada reticulata*, *Indigofera banii*, *Ormosia cambodiana*, *O. crassivalvis*, *O. vietnamensis*, *Pithecellobium vietnamense*),
- Fagaceae** (*Castanopsis cambodiana*, *Quercus cambodiensis*),
- Flacourtiaceae** (*Casearia tardieuae*, *Homalium brevidens*, *Hydnocarpus saigonensis*),
- Hamamelidaceae** (*Altingia cambodiana*),
- Lauraceae** (*Neolitsea cambodiana*),
- Loganiaceae** (*Strychnos polyantha*, *S. rupicola*, *Mitrasacme setosa*),
- Lowiaceae** (*Orchidantha vietnamica*),
- Molluginaceae** (*Gisekia pierrei*),
- Moraceae** (*Ficus phanrangensis*),
- Myrsinaceae** (*Ardisia albomaculata*, *A. cadieri*, *A. dinhensis*, *A. graciliflora*, *A. lauriformis*, *A. melastomoides*, *A. poilanei*, *A. psychotriaephylla*, *A. recliniflora*, *A. sauraujaefolia*, *A. splendens*),
- Myrtaceae** (*Cinnamomum cambodianum*),
- Nepenthaceae** (*Nepenthes kampotiana*),
- Pandanaceae** (*Pandanus ceratostigma*, *P. cornifer*, *P. cupribasalis*, *P. horizontalis*),
- Passifloraceae** (*Adenia poilanei*),
- Proteaceae** (*Helicia elephantii*),
- Rafflesiaceae** (*Sapria poilanei*),
- Sapotaceae** (*Aesandra dongnaiensis*, *A. lecomtei*, *Bumelia harmandii*, *Madhuca bejaudii*, *M. butyrospermoides*, *M. cambodiana*, *M. cochinchinensis*, *M. elliptica*, *M. firma*, *M. floribunda*, *M. kompongsonensis*, *M. thorelii*, *Payena annamensis*, *Xantolis maritima*),
- Scrophulariaceae** (*Limnophila cambodiana*, *L. poilanei*, *Lindernia aculeata*, *L. annamensis*, *L. cerastioides*, *L. harmandii*, *L. laotica*, *L. spathacea*, *L. umbellata*, *Pseudostriga cambodiana*, *Torenia vientianica*),
- Simaroubaceae** (*Samandera harmandii*),
- Smilacaceae** (*Smilax cambodiana*),
- Theaceae** (*Camellia fleuryi*, *C. nematodea*, *E. turfosa*),
- Thymelaeaceae** (*Wikstroemia austrocochinchinensis*).

Approximately 273 orchid species from 91 genera are known at present from the South Indochinese Province. Among them 23 species are local endemics of this area (Table 9).

Table 9. Orchid species reported from South Indochinese floristic province (local endemics of this area in bold)

<i>Acampe ochracea</i> ,	<i>A. rosea</i> ,	<i>Arundina chinensis</i> ,
<i>A. papillosa</i> ,	<i>Agrostophyllum planicaule</i> ,	<i>A. graminifolia</i> ,
<i>A. rigida</i> ,	<i>Aphyllorchis montana</i> ,	<i>Ascocentrum ampullaceum</i> ,
<i>Acanthephippium odoratum</i> ,	<i>Apostasia nuda</i> ,	<i>A. christensonianum</i> ,
<i>Acriopsis indica</i> ,	<i>A. odorata</i> ,	<i>A. garayi</i> ,
<i>A. liliifolia</i> ,	<i>A. wallichii</i> ,	<i>Bromheadia finlaysoniana</i> ,
<i>Aerides crassifolia</i> ,	<i>Appendicula cornuta</i> ,	<i>Brachycorythis laotica</i> ,
<i>A. falcata</i> ,	<i>A. hexandra</i> ,	<i>B. thorelii</i> ,
<i>A. houlettiana</i> ,	<i>Arachnis hookeriana</i> ,	<i>Bulbophyllum apodum</i> ,
<i>A. multiflora</i> ,	<i>A. labrosa</i> ,	<i>B. astelidum</i> ,
<i>A. odorata</i> ,	<i>A. maingayi</i> ,	<i>B. bariense</i> ,

- B. blepharistes*,
B. careyanum,
B. clandestinum,
B. delitescens,
B. evrardii,
B. flabellovenaris,
B. laoticum,
B. luanii,
B. macranthum,
B. macrocoleum,
B. morphologorum,
B. putidum,
B. retusiusculum,
B. rufinum,
B. sanguineopunctulatum,
B. sanitii,
B. spadiciflorum,
B. wallichii,
Calanthe angustifolia,
C. chevalieri,
C. rubens,
C. succedanea,
C. triplicata,
C. vestita,
Cheirostylis spathulata,
Christensonia vietnamica,
Cleisomeria lanatum,
Cteisostoma lendyanum,
C. racemiferum,
C. rostratum,
C. striatum,
C. williamsonii,
Coelogyne brachyptera,
C. trinervis,
Collabium chloranthum,
Cryptopylos clausus,
Cymbidium aloifolium,
C. ensifolium,
C. finlaysonianum,
C. lancifolium,
C. macrorrhizon,
Dendrobium acinaciforme,
D. aloifolium,
D. aphyllum,
D. capillipes,
D. christyanum,
D. chrysotoxum,
D. concinnum,
D. cretaceum,
D. crumenatum,
D. crystallinum,
D. delacourii,
D. draconis,
D. ellipsophyllum,
D. exile,
D. fimbriatum,
D. hamatum,
D. incurvum,
D. intricatum,
D. leonis,
D. lindleyi,
D. linguella,
D. lobbii,
D. lomatochilum,
D. mannii,
D. nathanielis,
D. palpebrae,
D. parciflorum,
D. porphyrophyllum,
D. pseudotenellum,
D. salaccense,
D. secundum,
D. simondii,
D. sociale,
D. stuartii,
D. thyrsoiflorum,
D. tortile,
D. uniflorum,
D. virgineum,
Dipodium paludosum,
Doritis pulcherrima,
Eparmatostigma dives,
Epigeneium cacuminis,
Eria bidupensis,
E. bractescens,
E. clausa,
E. cochinchinensis,
E. floribunda,
E. lasiopetala,
E. longipes,
E. paniculata,
E. pannea,
E. siamensis,
E. tenuiflora,
Erythrorchis ochobiensis,
Eulophia andamanensis,
E. flava,
E. graminea,
E. macrobulbon,
E. pauciflora,
E. pulchra,
E. spectabilis,
Flickingeria fimbriata,
Galeola nudifolia,
Gastrochilus obliquus,
G. yunnanensis,
Geodorum attenuatum,
G. densiflorum,
G. recurvum,
G. siamense,
Goodyera foliosa,
G. procera,
Grosourdyia appendiculata,
Habenaria acuífera,
H. commelinifolia,
H. dentata,
H. erostrata,
H. godefroyii,
H. lindleyana,
H. lucida,
H. malintana,
H. medioflexa,
H. myriotricha,
H. poilanei,
H. rhodocheila,
H. rostellifera,
H. rostrata,
H. rumphii,
H. viridiflora,
Hetaeria anomala,
H. oblongifolia,
H. rotundifolia,
Holcoglossum subulifolium,
Hygrochilus parishii,
Kingidium deliciosum,
Liparis acuminata,
L. acutissima,
L. balansae,
L. cespitosa,
L. kirromensis,
L. nigra,
L. oppositifolia,
L. regnieri,
L. rhombea,
L. viridiflora,
Ludisia discolor,
Luisia brachystachys,
L. filiformis,
L. morsei,
L. psyche,
L. zollingeri,
Malaxis acuminata,
M. ophridis,

<i>M. octodentata</i> ,	<i>P. eakroensis</i> ,	<i>Spathoglottis affinis</i> ,
<i>Malleola dentifera</i> ,	<i>P. rivesii</i> ,	<i>S. plicata</i> ,
<i>M. seidenfadenii</i> ,	<i>Peristylus australis</i> ,	<i>S. pubescens</i> ,
<i>M. sylvestris</i> ,	<i>P. constrictus</i> ,	<i>Spiranthes sinensis</i> ,
<i>Micropera pallida</i> ,	<i>P. densus</i> ,	<i>Staurochilus fasciatus</i> ,
<i>Microsaccus griffithii</i> ,	<i>P. subaphyllus</i> ,	<i>Sunipia pallida</i> ,
<i>Nervilia aragoana</i> ,	<i>Phaius tankervilleae</i> ,	<i>Taeniophyllum daroussinii</i> ,
<i>N. plicata</i> ,	<i>Pholidota articulata</i> ,	<i>T. obtusum</i> ,
<i>Neuwiedia annamensis</i> ,	<i>P. chinensis</i> ,	<i>Tainia angustifolia</i> ,
<i>N. singapureana</i> ,	<i>P. convallariae</i> ,	<i>Thecostele alata</i> ,
<i>Oberonia acaulis</i> ,	<i>P. imbricata</i> ,	<i>Thelasis micrantha</i> ,
<i>O. caulescens</i> ,	<i>P. leveilleana</i> ,	<i>T. pygmaea</i> ,
<i>O. gammiei</i> ,	<i>P. pallida</i> ,	<i>Thrixspermum centipeda</i> ,
<i>O. longibracteata</i> ,	<i>Platanthera angustata</i> ,	<i>Trias disciflora</i> ,
<i>O. lycopodioides</i> ,	<i>Podochilus microphyllus</i> ,	<i>T. nasuta</i> ,
<i>O. pachyphylla</i> ,	<i>Polystachya concreta</i> ,	<i>Trichoglottis retusa</i> ,
<i>O. rufilabris</i> ,	<i>Pomatocalpa grandis</i> ,	<i>T. seidenfadenii</i> ,
<i>O. trochopetala</i> ,	<i>Porpax ehwesii</i> ,	<i>Trichotosia dasyphylla</i> ,
<i>Ornithochilus difformis</i> ,	<i>Renanthera coccinea</i> ,	<i>T. microphylla</i> ,
<i>O. delavayi</i> ,	<i>R. imschootiana</i> ,	<i>T. pulvinata</i> ,
<i>Otochilus fuscus</i> ,	<i>Rhynchostylis coelestis</i> ,	<i>T. velutina</i> ,
<i>Pachystoma pubescens</i> ,	<i>R. gigantea</i> ,	<i>Tropidia angulosa</i> ,
<i>Panisea albiflora</i> ,	<i>R. retusa</i> ,	<i>T. curculigoides</i> ,
<i>Paphiopedilum appletonianum</i> ,	<i>Robiquetia spathulata</i> ,	<i>Vanda lilacina</i> ,
<i>Papilionanthe hookeriana</i> ,	<i>R. succisa</i> ,	<i>Vandopsis gigantea</i> ,
<i>P. teres</i> ,	<i>Sarcoglyphis mirabilis</i> ,	<i>Vanilla albida</i> ,
<i>Pecteilis cambodiana</i> ,	<i>Schoenorchis gemmata</i> ,	<i>V. annamica</i> ,
<i>P. cochinchinensis</i> ,	<i>Smitinandia helferi</i> ,	<i>Vrydagzynea albida</i> .
<i>Pelatantheria ctenoglossum</i> ,	<i>S. micrantha</i> ,	

It should be mentioned that mountain areas of southern Cambodia including the Chour Phnum Kravanh (Cardamom) and Chour Phnom Damrei (Elephant) Mountains are obviously distinctly different from other floristic regions of the South Indochinese Province. This area has an unusually high level of annual rainfall supporting lowland rain and very wet thermophilous montane forests that greatly differ from other types of vegetation of the area. According to their structure and species composition, these forests may be florogenetically treated as depauperate forms of Indomalaysian rainforest. In many respects this region, designated as the Cardamom Mountains Wet Forest (Wikramanayake *et al.* 1997), should be regarded as an isolated northern enclave of the Malay Floristic Province of the Malesian Region on the floristic divisions of Takhtajan (1978, 1986). Only a small area within Vietnam – Phu Quoc Island – also belongs to this area. Well-developed relatively rich mangrove communities can be observed along the coastline of the area (Dy Phon 1970) and reinforce its sub-equatorial character. The most common species within mangrove thickets are the following:

<i>Acanthaceae</i> (<i>Acanthus ebracteatus</i> ,	<i>Euphorbiaceae</i> (<i>Excoecaria agallocha</i> ,
<i>A. ilicifolius</i>),	<i>Glochidion littorale</i>),
<i>Adiantaceae</i> (<i>Acrostichum aureum</i>),	<i>Fabaceae</i> (<i>Azelia xylocarpa</i>),
<i>Arecaceae</i> (<i>Licuala spinosa</i> , <i>Nypa fruticans</i> ,	<i>Malvaceae</i> (<i>Hibiscus tiliaceus</i>),
<i>Phoenix paludosa</i>),	<i>Meliaceae</i> (<i>Xylocarpus granatum</i>),
<i>Celastraceae</i> (<i>Salacia viminea</i>),	<i>Myrsinaceae</i> (<i>Aegiceras corniculata</i>),
<i>Combretaceae</i> (<i>Lumnitzera littorea</i> ,	<i>Rhizophoraceae</i> (<i>Bruguiera gymnorhiza</i> ,
<i>Lumnitzera racemosa</i>),	<i>B. sexangula</i> , <i>Ceriops decandra</i> ,

C. tagal, *Rhizophora apiculata*,
Rh. conjugata, *Rh. mucronata*),
 Rubiaceae (*Scyphiphora hydrophyllacea*),
 Simaroubaceae (*Samadera harmandii*),

Sonneratiaceae (*Sonneratia alba*,
S. caseolaris, *S. ovata*),
 Verbenaceae (*Avicennia alba*, *Clerodendron*
inerme).

Similarly coastal strand vegetation developed within the South Indochinese Province has an obviously sub-equatorial woody and shrub species composition including:

Aquifoliaceae (*Ilex wallichii*),
 Apocynaceae (*Cerbera odollam*),
 Arecaceae (*Caryota urens*, *Licuala spinosa*,
Oncosperma tigillaria, *Phoenix*
paludosa),
 Casuarinaceae (*Casuarina equisetifolia*),
 Clusiaceae (*Calophyllum inophyllum*,
C. retusum),
 Combretaceae (*Terminalia catappa*),
 Cycadaceae (*Cycas rumphii*),
 Euphorbiaceae (*Excoecaria agallocha*,
Glochidion rubrum),
 Fabaceae (*Sindora maritima*),
 Lecythidaceae (*Barringtonia acutangula*,
B. angusta, *B. pauciflora*),

Lythraceae (*Pemphis acidula*),
 Malvaceae (*Hibiscus tiliaceus*),
 Melastomataceae (*Melastoma sanguineum*),
 Meliaceae (*Amoora cucullata*),
 Myrsinaceae (*Rapanea capitellata*),
 Myrtaceae (*Syzygium polyanthum*,
S. zeylanicum),
 Ochnaceae (*Ochna integerrima*),
 Pandanaceae (*Pandanus tectorius*),
 Podocarpaceae (*Podocarpus fleuryi*),
 Rubiaceae (*Hypobathrum frutescens*),
 Sapotaceae (*Manilkara hexandra*),
 Simaroubaceae (*Samadera harmandii*),
 Sterculiaceae (*Heritiera javanica*,
H. littoralis).

A moderate diversity of epiphytes, mainly ferns and orchids, is sometimes observed in these forests. Among herbs in wetter areas of this habitat is *Leptocarpus disjunctus*, one of the few members of the *Restionaceae* to reach the Northern Hemisphere (Hozumi *et al.* 1969; Dy Phon 1970).

8. Conclusion

Based on the available information and analysis of selected families, data on the level of local endemism observed within the floras of defined floristic provinces are presented schematically in Fig. 4. From this figure the highest level of endemism is observed in the flora of the South Chinese floristic province. About 32.7% of all known Vietnamese endemics occur in this province and approximately 11.6% are strict endemics of this area. The floras of the North Indochinese, Central Annamese, South Annamese and South Indochinese provinces also have a very high, but relatively moderate endemic component. The area with lowest number of endemic species is the Sikang–Yunnan Province. This relatively low level of endemism is due to the fact that only a small area occurs within the Vietnamese portion of this province. However, the absolute level of endemism for the total area of this province, lying mainly in China, is certainly very high.

The closest floristic relationships are observed between the South Chinese and the North Indochinese floristic provinces, sharing nearly 13.8% of the common Vietnamese endemics occurring in both provinces. Considerably affinity in endemic species is also evident between the Central Annamese and the South Annamese provinces (about 8.6%), the North Indochinese and the Central Annamese provinces (about 7.9%), and the Sikang–Yunnan and the South Chinese provinces (about 7.6%). The lowest levels of floristic relations are between the Sikang–Yunnan and the South Indochinese Province (about 4%), Sikang–Yunnan and South Annamese provinces (about 1.7%), Sikang–Yunnan and Central Annamese province, and the South Chinese and South Indochinese Province (both about 2.4% of common endemics).

On the basis of the floristic analysis, the absolute richness of endemic species in defined floristic units depends on the diversity of the habitats and the extent of the floristic province. The level of floristic relationships depends primarily on the distance between the regions compared

(Fig. 3, 4). In general, all floristic units distinguished have an outstanding level of strict local endemism, defining these phytogeographic regions as very diverse and unique important centres of plant diversity.

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