

MOHAMED BIN ZAYED SPECIES CONSERVATION FUND

CONSERVATION ASSESSMENT OF ENDANGERED LAO-VIETNAMESE STENOENDEMIC – *PINUS CERNUA* (PINACEAE)

IDENTIFICATION OF DISTRIBUTION, POPULATION STRUCTURE,
HABITAT LOSS, BIOME SIGNIFICANCE

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SCIENTIFIC REPORT
2016



صندوق محمد بن زايد
للمحافظة على الكائنات الحية
The Mohamed bin Zayed SPECIES CONSERVATION FUND



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Conservation assessment of endangered Lao-Vietnamese stenoendemic – *Pinus cernua* (Pinaceae)

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Resume. The report presents completed conservation assessment of the strict Laos-Vietnamese endemic, *Pinus cernua* based on survey of all early publications and data obtained from extensive fieldworks during September – October 2016, supported by Mohamed bin Zayed Species Conservation Fund, Komarov Botanical Institute of the Russian Academy of sciences and The Center for Plant Conservation of the Vietnam Union of Science and Technology Associations. Present review verified 23 locations of the species in Pha Luong Mountains situated on the state boundary of Vietnam (Son La province) and Laos (Houaphan province). Among available localities, 6 were found at first, the species extinction was detected in 1 locality. The area of the species distribution decreased during last 3-5 years on 25-30% from about 20 to 15 km², with total occupancy area less than 3 km², therefore species conservation status is assessed as globally critically endangered (CR) following to accepted IUCN Red List categories and criteria: B1(a, b i-v), B2(a, b i-v). Report also provides basic data on geography, geomorphology and climate of Pha Luong Mountains, as well as detailed descriptions of *P. cernua* ecology, habitats, vegetation, biology, population structure and taxonomy. All field data and descriptions are based on collected voucher herbaria, which belong to 99 families, 180 genera and 550 species. Among collected plants, 6 species are new for the flora of Vietnam, 30 species are local threatened endemics needed protection and 12 species are new for science. The main factors of *P. cernua* extinction are formulated and the recommendations for its effective protection are proposed.

INTRODUCTION

Uplifted landmasses in eastern Indochina form a series of more or less high ridges known today as the Truong Son or Annamese Range. These highlands stretch as a southeastern extension of the Himalayas for more than 1000 km from the mountainous areas of Yunnan across the entire peninsular territory to the seashore of southern Cambodia. During the long and complicated geological history, these mountain chains, running in a longitudinal direction, created a corridor for repeated plant movements from subtropical and temperate Asia to tropical highlands of eastern Indochina. Ancient species migrations and isolation within many mountain systems resulted in active processes of species formation in this area (Averyanov et al., 2003). Isolation of representatives of a number of temperate Asian or Holarctic genera led to the creation of numerous endemic and sub-endemic taxa within highest mountain systems of eastern Indochina. Diversity and distribution patterns of pine species (*Pinus* L.) within eastern Indochina is an evident example of such migrations and subsequent isolation within a number of more or less isolated mountain massifs. As a result, eastern Indochina may constitute the region of the world with the highest pine diversity (Farjon, 2001; Hiep, Vidal, 1996; Hiep et al., 2004; Luu, Thomas, 2004; Phan Ke Loc et al., 2013; Averyanov et al., 2015a).

At least 12 native *Pinus* species and varieties were inventoried within this territory during recent explorations, observations and taxonomic studies (Businsky, 2013, 2016, pers. Comm.; Phan Ke Loc et al., 2013; Averyanov et al., 2015a). Additionally the highlands of southern Vietnam in limits of Lam Dong, Dac Lac and Khanh Hoa provinces provide a home to *Ducampopinus krempfii* (Lecomte) A. Chev., a unique relictual endemic of Chu Yang Sin and Bi Dup Mountains. This peculiar primitive pine is possibly allies to ancestral complex of all modern pines (Orlova, Averyanov, 2004). Four well defined allopatric varieties of the endemic *Pinus dalatensis* Ferré – *P. dalatensis* var. *dalatensis*, var. *anemophila* (Businsky) Aver., var.

bidoupeensis Businsky and var. *procera* (Businsky) Aver. inhabit isolated mountain areas within southern and central Vietnam and in Laos. A number of isolated massifs of rocky karstic limestone in northern Vietnam and in adjacent regions of China represent the area of distribution of the subendemic *P. henryi* Masters and four calcium-dependent endemic races of *P. wangii* Hu et W.C. Cheng – *P. wangii* var. *wangii*, var. *kwangtungensis* (Tsiang) Silba, var. *varifolia* (Nan Li et Y.C. Zhang) Aver. and var. *eremitana* (Businsky) Aver. Two widespread species, *Pinus kesiya* Gordon and *P. latteri* Mason, occasionally form scattered mixed and coniferous forests throughout Indochina. Meanwhile, many mountainous areas of eastern Indochina, particularly regions along the border with Vietnam remain insufficiently explored because they are often inaccessible for botanists. Such areas certainly contain the potential for the discovery of numerous local endemic plants during future scientific explorations including pine species.

Ancient table-shaped sandstone formations occurring sporadically in northern and central Vietnam and Laos represent particular interest for pine geographic investigation. These formations resulted in ancient tectonic breaks of sediment sandstone plates and represent faults, which presently have form of more or less continuous table-shaped formations uplifted to 600-1800 m a.s.l. Commonly such formations in eastern Indochina are oriented in more or less longitudinal direction and have cliffy to almost vertical margin at least from on one side (commonly on north faced slope). Summits of such formations are often almost flat. However, in some cases uplifted plateaus are dissected by deep rifts or even eroded into a peneplain with numerous rocky mesas in its peripheral zone. Thin sandy, poor, well-drained soils rich in quartzite are favorable for conifers and provide suitable conditions for pine species, which often form here mixed and true coniferous zonal primary forests. Earlier floristic studies detected such primary indigenous coniferous forests on sandstone with endemic varieties of *Pinus dalatensis* in Quang Binh (Minh Hoa district, voucher herbarium specimens – HAL 11783, year 2008, d-EXSICCATES OF VIETNAMESE FLORA 0121/HAL 11783) and Quang Nam (Dai Loc district, voucher herbarium specimen – CPC 3575, year 2011) provinces in central Vietnam and Laos (Businsky, 2010). However, highest sandstone formation of mentioned type known as Pha Luong Mountains situated on Laos-Vietnamese border between Houaphan and Son La provinces a long time remains insufficiently investigated. Meanwhile, new endemic pine species – *Pinus cernua* was reported from this area recently as an important co-dominant of indigenous coniferous forests (Averyanov et al., 2014, 2015). Detailed assessment of this strictly endemic species was undertaken in present study supported by Mohamed bin Zayed Species Conservation Fund.

POSITION AND LAND FORMS OF PHA LUONG MOUNTAINS

Pha Luong mountain system occupies territory roughly estimated as approximately 40-45 km², which extends on 4-5 km from the S to the N (between 20°40'00'' and 20°42'50''N) and on about 10 km from the W to the E (between 104°36'30'' and 104°41'40''E). Administratively Pha Luong Mountains in their main territory belong to Son La province, Moc Chau district, Chieng Son commune (municipality) and Van Ho district, Tan Xuan commune (municipality) of Vietnam. Southern mountain system slopes in smallest part belong to Houaphan province, Xam Neua district (Lao PDR). Eastern part of Pha Luong Mountains is included presently into main and buffer zones of Xuan Nha nature reserve (Vietnam).

On their geomorphology, Pha Luong Mountains represent uplifted well-developed peneplain with many picturesque exposed rocky peaks, deep rifts with vertical cliffs, rocky outcrops and numerous crowded mesas composed with red-brown highly eroded sandstone. Main summit of mountain massif has appearance of uplifted table-shaped plateau with highest point at SW margin elevated to 1869 m a.s.l. (fig. 1, 2). Sandstone plateau dissected by numerous rifts on its margin and composed on periphery with eroded mesas, rocky peaks and impressive exposed cliffs (fig. 3-7). Tall open vertical cliffs with many lithophytic plant species

are very typical landforms in any part of mountains (fig. 8, 9). Almost all mountain body composed by solid red-brown highly eroded sandstone with many giant roller boulders, caves and overhanging eroded platforms (fig. 10-12). Few karstic limestone rocks also occasionally observed in this area, but lime outcrops here are rather rare.

CLIMATE OF PHA LUONG MOUNTAINS

Climate in the area of Pha Luong Mountains is classified in national climatology as “monsoon tropical climate with cold winter and summer rain season” (Nguyen Khanh Van et al., 2000). Mean annual precipitation is about 1560 m and mean annual temperature is 18.5°C, with five cold and dry winter months (from November to March). Detailed climate data recorded in nearest meteorology station in Moc Chau town at elevation 958 m a.s.l. – may be found in monograph of Nguyen Khanh Van et al. (2000, page 71, diagram 55). Basic data on mean month temperatures and precipitation recorded in this monograph are presented in table 1. Absolute temperature maximum recorded here is +35°C, and absolute minimum –1.5°C. Cloudy fogs and mists are very common at high elevations in Pha Luong Mountains (fig. 107) that provides almost permanent high humidity favorable for rich epiphytic and lithophytic vegetation observed near mountaintop.

Table 1.

Data on mean month temperatures and precipitation in the area of Pha Luong Mountains

(The months are designated by Roman numerals, temperature – in °C, and rainy precipitation in mm)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Temperature	11.8	13.3	16.8	20.2	22.5	23.0	23.1	22.4	21.2	18.9	15.7	12.8
Precipitation	14.8	21.2	34.0	98.7	165.5	220.8	266.3	331.4	257.2	106.4	31.8	11.8

MAIN TYPES OF VEGETATION IN PHA LUONG MOUNTAINS

Evergreen tropical submontane broad-leaved, mixed and coniferous forests are main aboriginal zonal kinds of primary vegetation in Pha Luong Mountains. Presently, on largest part of the territory, they are replaced by different kinds of secondary plant communities, pastures and agricultural fields. Primary broad-leaved more or less degraded forests still survives here on steep slopes at elevation from 600-700 to 1700-1800 m a.s.l. Mixed and coniferous primary forests grow in Pha Luong Mountains at elevations 800-1550 m a.s.l. Specific zonal plant formations, like wind-formed broad-leaved cloud forests and ericaceous scrub are observed on highest mountain tops elevated to 1700-1860 m. Secondary azonal bamboo and herbaceous, grassland-like plant communities occupy highland rocky outcrops in places cleaned by forest fires. Main kind of plant communities in studied area are follow:

Zonal (elevational) plant communities:

1. Evergreen broad-leaved tropical submontane forest
2. Evergreen mixed tropical submontane forest
3. Evergreen coniferous tropical submontane forest
4. Evergreen broad-leaved tropical cloud montane forest
5. Evergreen ericaceous montane scrub

Azonal plant communities

6. Bamboo montane thickets
7. Sphagnum-herbaceous montane grassland

Structure and composition of main aboriginal plant communities in Pha Luong Mountains

1. Evergreen broad-leaved tropical submontane forest (fig. 13-15, 18, 19; Appendix 1, 1)

This kind of forest spreads in Pha Luong area at elevations (500)600-1750(1800) m on slopes of any exposition inclined commonly to 0-40(50)°. Parental soil material in all area is solid red-brown sandstone. Leaf litter usually 0-5 cm thick with projected coverage to 100%. Soils rather thin and poor, well drained, with brown humus-containing horizon about (20)30-40(50) cm. Forest structure includes commonly 5 strata with rich non strata vegetation.

First forest stratum includes trees 15-30(35) m tall, (30)40-110(120) cm DBH forming projective coverage 30-60(70)%. Main dominants of first forest stratum are – *Castanopsis* ssp., *Cinnamomum* ssp., *Diplopanax vietnamensis* (fig. 60), *Lithocarpus* ssp., *Parakmeria robusta* (fig. 58, 59), *Quercus* ssp. (fig. 64), *Sloanea* sp. with more or less usual associates, such as – *Eberhardtia* sp., *Gordonia* sp., *Liquidambar formosanum*, *Litsea* ssp., *Schima wallichii*, *Styrax* sp.

Second stratum includes trees 5-15 m tall, (7)10-30(40) cm DBH forming project coverage 30-70(80)%. No any certain dominant trees are observed in this stratum, but more or common species are – *Acer* sp., *Aglaia* ssp., *Antidesma* sp., *Camellia* sp., *Citrus* sp., *Diospyros* sp., *Ficus gibbosa*, *Livistona chinensis*, *Magnolia foveolata*, *Magnolia megaphylla*, *Magnolia* ssp., *Manglietia dandyi*, *Michelia balansae*, *Michelia* ssp., *Ormosia* sp., *Symplocos* sp. and *Wikstroemia* sp.

Third (shrub) stratum consists of treelets and shrubs 2-5 m tall forming projective coverage 10-40(50)%. Dominant species here are – *Blastus* ssp., *Ixora* sp., *Lasianthus* sp., *Licuala* sp. and *Psychotria* ssp. with regular associates, such as – *Ardisia* ssp., *Chloranthus* sp., *Clausena* sp., *Croton* sp., *Dichroa febrifuga*, *Medinilla* sp., *Oxyspora* ssp., *Pinanga* sp., *Polygala* sp., *Rhapis* sp., *Sarcandra glabra*, *Schefflera* sp., *Silvianthus tonkinensis* and *Staphyllea* sp.

Fourth (herbaceous) stratum includes herbaceous and semi-herbaceous plants from 3 cm to 2 m tall. This stratum forms projective coverage (0)5-20(35)%. Most common herb species here are: *Alpinia* sp., *Aspidistra nutans*, *Aspidistra* sp., *Aspidistra subrotata*, *Begonia delavayi*, *Begonia handelii*, *Begonia hemsleyana*, *Begonia howii*, *Begonia* sp., *Begonia tetragona*, *Colysis* sp., *Diplasium* sp., *Diplazium donianum*, *Elatostema* ssp., *Leptochylus* sp., *Microlepis* sp., *Mycetia* ssp., *Ophiopogon* ssp., *Ophiorrhiza* ssp., *Peliosanthes griffithii*, *Peliosanthes* ssp., *Pellionia* ssp., *Phyllagathis pulchella* sp. nov. (fig. 79, 80), *Polystichum* sp., *Pteris* sp., *Selaginella* sp., *Sonerila* ssp. and *Spatholirion puluongense* (fig. 75, 76). More or less usual associates in this stratum are – *Anoetochilus annamensis*, *Anoetochilus roxburghii*, *Apostasia wallichii*, *Aspidistra bifolia*, *Calanthe alleizettii*, *Calanthe clavata*, *Calanthe densiflora*, *Calanthe puberula*, *Calanthe* sp., *Calanthe sylvatica*, *Clerodendron* ssp., *Cymbidium ensifolium*, *Cymbidium kanran*, *Cymbidium lancifolium*, *Disporum* sp., *Geodorum* sp., *Gomphostemma* sp., *Goodyera foliosa*, *Habenaria medioflexa*, *Habenaria* sp., *Impatiens* sp., *Kaempferia rotunda*, *Lindsaea orbiculata*, *Liparis nervosa*, *Nervilia aragoana*, *Ophiopogon alatus*, *Ophiopogon intermedius*, *Ophiopogon tonkinensis*, *Peliosanthes kenhilloides*, *Phyllagathis* sp., *Rhomboda petelotii*, *Streptolirion volubile*, *Tainia latifolia*, *Zeuxine nervosa*, *Zingiber cochleariforme*, *Zingiber guangxiense* and *Zingiber recurvatum*.

Fifth stratum (mosses & lichens) is very thin, not exceeding 3 cm tall. It varies from (0.1)0.5-3 cm and covers ground with projective coverage on 0-80(100)%. Beside the indeterminable mosses (mainly in protonema stage) in includes few species of tiny ferns – *Crepidomanes auriculatum*, *Mecodium* sp. and *Trichomenes* sp. (Hymenophyllaceae).

Non strata vegetation includes numerous epiphytes and lithophytes:

Dominant epiphytic species:

Asplenium nidus (fig. 65), *Bulbophyllum ambrosia*, *Bulbophyllum psychoon*, *Bulbophyllum* ssp., *Callostylis rigida*, *Ceratostylis himalaica*, *Coelogyne fimbriata*, *Davallia* sp.,

Dendrobium chrysanthum, *Dendrobium nobile*, *Dendrobium spatella*, *Dendrobium thyrsiflorum*, *Dischidia* sp., *Drynaria* sp., *Epigeneium amplum*, *Epigeneium chapaense*, *Eria pannea*, *Eria siamensis*, *Eria* ssp., *Eria thao*, *Hoya* sp., *Lemmaphyllum microphyllum*, *Lepisorus* sp., *Liparis viridiflora*, *Microsorium* sp., *Panisea* ssp., *Peperomia* sp., *Pholidota articulata*, *Pholidota chinensis*, *Pyrrosia* sp., *Thelasis pygmaea* and *Thrixspermum centipeda*.

Associated epiphytic species:

Aeschynanthus mendumiae, *Aeschynanthus* ssp., *Bulbophyllum apodum*, *Bulbophyllum biesetoides*, *Bulbophyllum pecten-veneris*, *Bulbophyllum reptans*, *Cleisostoma striatum*, *Cleisostoma williamsonii*, *Coelogyne* ssp., *Cymbidium lowianum*, *Cymbidium* ssp., *Dendrobium brymerianum*, *Dendrobium eriiflorum*, *Dendrobium falconeri*, *Dendrobium fimbriatum*, *Dendrobium hancockii*, *Dendrobium jenkinsii*, *Eria apertiflora*, *Eria calcarea*, *Eria rhomboidalis*, *Huperzia* sp., *Hygrochilus parishii*, *Liparis longispica*, *Liparis pumila*, *Luisia* ssp., *Luisia zollingeri*, *Lycopodium* sp., *Lysionotus chingii*, *Oberonia falconeri*, *Oberonia* ssp., *Ornithochilus difformis*, *Pholidota recurva*, *Scindapsus* sp., *Smitinandia helferi*, *Stereochilus brevirachis*, *Sunipia scariosa*, *Thrixspermum stelidioides*, *Trichotosia microphylla*, *Trichotosia pulvinata* and *Vanda* sp.

Dominant lithophytic species:

Antrophyum sp., *Argostemma* ssp., *Asplenium antrophioides*, *Asplenium rupestre*, *Asplenium* sp., *Carex* sp., *Chirita* ssp., *Didymocarpus* sp., *Eria globulifera*, *Eria siamensis*, *Hedyotis* ssp., *Liparis bootanensis*, *Liparis viridiflora*, *Peperomia* sp., *Rhynchotechum* sp., *Sonerila* ssp., *Vittaria hainanensis* and *Vittaria* sp.

Associated lithophytic species:

Aglamorpha acuminata, *Appendicula hexandra*, *Boea* ssp., *Calcareaoboea coccinea*, *Collabium chapaensis*, *Collabium chinense*, *Eria bambusifolia*, *Eria calcarea*, *Eria carinata*, *Eria corneri*, *Eria rhomboidalis*, *Flickingeria fimbriata*, *Hedychium* sp., *Hedychium yunnanense*, *Lilium poilanei*, *Liparis averyanoviana*, *Liparis balansae*, *Liparis dendrochiloides*, *Liparis superposita*, *Oreocharis argyrophylla* (fig. 68), *Oreocharis blepharophylla* (fig. 69), *Oreocharis* sp., *Paraboea* sp., *Streptocarpus* sp. and *Vittaria elongata* (fig. 10).

Among woody and semi-woody vines and scandent shrubs were observed – *Actinidia* sp., *Alphonsea* sp., *Artobotrys* sp., *Illigera* sp. and *Popovia* sp. However, all these species are rather uncommon. Rocky habitats along narrow wet shady stream canyons provide home to many ferns including such species as – *Angiopteris evecta*, *Bolbithis* sp., as well as *Tupistra khangii* and *Tupistra* sp. Among specific living forms in forest of this kind were observed achlorophyllous root parasites – *Balanophora laxiflora* and *Balanophora* sp., as well as achlorophyllous mycotrophic plants – *Didymoplexis pallens*, *Gastrodia khangii* (fig. 72, 73, 96) and *Lecanorchis vietnamica*.

On very steep cliffy slopes near mountaintops and summits rocky outcrops become dominant against soil cover. In such conditions project coverage of all tree forest strata decrease, but lithophytes become abundant in species and ground coverage (fig. 18, 19).

2. Evergreen mixed tropical submontane forest (Appendix 1, 2)

Mixed forest in Pha Luong Mountains occurs at elevations (800)900-1500(1550) m on slopes of any exposition with inclination commonly 0-70(80)°. In all observed localities, soils of forest habitats are derived on solid red-brown sandstone. Leaf litter here is 0-3 cm thick with projected coverage from 0 to 100% in small depressions. Soils thin, poor, well drained, with brown humus-containing horizon (5)10-20(30) cm.

Main co-dominants of first forest stratum are broad-leaved trees like *Acer* sp., *Castanopsis* ssp., *Cinnamomum* ssp., *Diplopanax vietnamensis* (fig. 60), *Gordonia* sp., *Lithocarpus* ssp., *Litsea* ssp., *Quercus* ssp. (fig. 64) and *Schima wallichii*. They reach 15-30(35) m tall and (30)35-45(60) cm DBH with total projective stratum coverage 30-60(70)%. Coniferous component in these forests includes such species as *Amentotaxus argotaenia*,

Amentotaxus yunnanensis, *Cephalotaxus mannii*, *Dacrycarpus imbricatus*, *Fokienia hodginsii* (fig. 16, 61, 62), *Keteleeria evelyniana*, *Pinus cernua* (fig. 17, 30-57), *Pinus latteri*, *Podocarpus neriifolius*. Most of them sporadically scattered among broad-leaved trees as more or less rare associates.

Second stratum of mixed forest has no certain dominants and includes such species as *Acer* sp., *Aglaiia* ssp., *Eriobotrya* sp., *Livistona chinensis*, *Photinia cucphuongensis* (fig. 74), *Schefflera* sp., *Symplocos* sp. and *Wikstroemia* sp. 5-15 m tall and (7)10-20(25) cm DBH. Projective coverage of this stratum is (15)20-45(55)%.

Third (shrub) stratum includes treelets and shrubs 2-5 m tall. It has projective coverage 10-30(40)%. Most common dominants here are – *Ixora* sp., *Lasianthus* sp., and *Psychotria* ssp. With such associates as – *Ardisia* ssp., *Camellia* sp., *Lasianthus* sp., *Licala* sp., *Oxyspora* sp., *Psychotria* ssp., *Schefflera* sp.

Fourth stratum (herbs) includes herbaceous species 0.03-2 m tall. Projective coverage of this stratum varies from 0 to 30%. Most common here are *Diplasium* sp., *Elatostema* ssp., *Microlepia* sp., *Pellionia* ssp., *Polystichum* sp., *Selaginella* sp. As more or less common associated were observed such species as *Alpinia* sp., *Goodyera schlechtendaliana*, *Ophiorrhiza* ssp., *Sonerila* ssp., *Tainia latifolia*, *Zingiber cochleariforme*, *Zingiber guangxiense*, *Zingiber recurvatum*.

Fifth stratum includes indeterminable mixture of juvenile mosses and lichens (0.1)0.5-3 cm tall with coverage 10-80(100)% as well as few tiny ferns – *Trichomenes* sp. (Hymenophyllaceae).

Non strata vegetation includes numerous epiphytes and lithophytes:

Dominant epiphytic species:

Bulbophyllum ambrosia, *Bulbophyllum reptans*, *Callostylis rigida*, *Ceratostylis himalaica*, *Coelogyne fimbriata*, *Davallia* sp., *Dendrobium spatella*, *Dendrobium thyrsiflorum*, *Dischidia* sp., *Drynaria* sp., *Epigeneium amplum*, *Epigeneium chapaense*, *Eria pannea*, *Eria siamensis*, *Eria* ssp., *Eria thao*, *Lemmaphyllum microphyllum*, *Lepisorus* sp., *Microsorium* sp., *Pholidota articulata*, *Pholidota chinensis*, *Pholidota recurva*, *Pyrrosia* sp. and *Thelasis pygmaea*.

Associated epiphytic species:

Aeschynanthus mendumiae, *Aeschynanthus* ssp., *Bulbophyllum apodum*, *Bulbophyllum biesetoides*, *Bulbophyllum pecten-veneris*, *Bulbophyllum psychoon*, *Bulbophyllum* ssp., *Cleisostoma striatum*, *Cleisostoma williamsonii*, *Coelogyne* ssp., *Cymbidium* ssp., *Dendrobium brymerianum*, *Dendrobium chrysanthum*, *Dendrobium falconeri*, *Dendrobium fimbriatum*, *Dendrobium hancockii*, *Dendrobium nobile*, *Eria apertiflora*, *Eria bambusifolia*, *Hoya* sp., *Huperzia* sp., *Hygrochilus parishii*, *Liparis longispica*, *Liparis pumila*, *Liparis viridiflora*, *Luisia* ssp., *Luisia zollingeri*, *Lycopodium* sp., *Oberonia falconeri*, *Oberonia* ssp., *Ornithochilus difformis*, *Panisea* ssp., *Peperomia* sp., *Smitinandia helferi*, *Stereochilus brevirachis*, *Sunipia scariosa*, *Thrixspermum stelidioides*, *Trichotosia microphylla*, *Trichotosia pulvinata* and *Vanda* sp.

Dominant lithophytic species:

Asplenium antrophioides, *Asplenium rupestre*, *Carex* sp., *Eria carinata*, *Eria globulifera*, *Eria siamensis*, *Flickingeria fimbriata*, *Liparis averyanoviana*, *Liparis bootanensis*, *Liparis viridiflora*, *Pyrrosia* ssp., *Vittaria hainanensis* and *Vittaria* sp.

Associated lithophytic species:

Antrophium sp., *Appendicula hexandra*, *Argostemma* ssp., *Asplenium* sp., *Boea* ssp., *Chirita* ssp., *Collabium chapaensis*, *Collabium chinense*, *Cymbidium lowianum*, *Didymocarpus* sp., *Eria bambusifolia*, *Eria calcarea*, *Eria corneri*, *Hedychium* sp., *Hedychium yunnanense*, *Hedyotis* ssp., *Lilium poilanei*, *Liparis balansae*, *Liparis dendrochiloides*, *Liparis superposita*, *Oreocharis argyrophylla*, *Oreocharis blepharophylla*, *Oreocharis* sp., *Paraboea* sp., *Peperomia* sp., *Rhynchotechum* sp., *Sonerila* ssp., *Streptocarpus* sp. and *Vittaria elongata*.

Among plants of specific living forms should be mentioned woody and semi-woody lianas like *Actinidia* sp., *Dioscorea* sp., *Smilax* sp. and *Tetrastigma* sp. All they in primary intact forest are rather uncommon.

3. Evergreen coniferous tropical submontane forest (fig. 16, 17; Appendix 1, 3)

Fragments of true coniferous forest in Pha Luong Mountains cover very small highly fragmented, mosaic rocky areas at elevations (800)900-1500(1550) m. Commonly they covers very steep to almost vertical cliffs with inclination 70-90° and rocky tops of remnant mesas composed exclusively red-brown sandstone (fig. 17, 38, 39, 49-51, 55, 56). Leaf litter here may be 0-3 cm thick with projected coverage 0-100%. Soil is very thin, well drained, with brown humus-containing horizon (5)10-20(30) cm.

Only two tree species – *Fokienia hodginsii* and *Pinus cernua* form first stratum of coniferous forests in Pha Luong Mountains. These trees reach 12-20(25) high and (30)35-60(80) cm DBH. Commonly they form rather open forests with projective coverage of first stratum in 15-35(45)%. As a more or less common associates here were observed such species as *Acer* sp., *Amentotaxus argotaenia*, *Amentotaxus yunnanensis*, *Camellia* sp., *Castanopsis* ssp., *Cephalotaxus mannii*, *Cinnamomum* ssp., *Dacrycarpus imbricatus*, *Gordonia* sp., *Lithocarpus* ssp., *Litsea* ssp., *Podocarpus neriifolius*, *Quercus* ssp., *Schefflera* sp., *Schima wallichii* and *Symplocos* sp. The second pine species – *Pinus latteri* was observed as occasional coniferous forest co-dominant on very limited square at elevation 800-1000 m a.s.l. among degraded secondary vegetation on southern marginal slopes of Pha Luong Mountains allied to agricultural area (Nguyen Minh Tam, Phan Ke Loc, Vu Dinh Duy, 2015; Businsky, 2016).

Second coniferous forest stratum has no certain dominants. Occasional species here except few immature conifers are – *Acer* sp., *Aglaia* ssp., *Eriobotrya* sp., *Lithocarpus* ssp., *Photinia cucphuongensis*, *Quercus* ssp., *Schefflera* sp., *Symplocos* sp. These trees have trunks 5-12 m tall, with (7)10-20(25) cm DBH. Usual projective coverage of this stratum – (15)23-50(60)%.

Third (shrub) stratum in coniferous forest includes treelets and shrubs 2-5 m tall and forms canopy coverage (10)15-40(45)%. It has no certain dominants and occasionally includes such species as – *Ardisia* ssp., *Camellia* sp., *Eriobotrya* sp., *Gaultheria fragrantissima*, *Gaultheria* sp., *Ilex* sp., *Leucothoe* sp., *Lyonia ovalifolia*, *Lyonia* ssp., *Oxyspora* sp., *Photinia cucphuongensis*, *Psychotria* ssp., *Rhododendron* ssp., *Schefflera* sp.

Fourth forest stratum includes herbaceous species 0.03-2 m tall covering ground on (0)5-15(25)%. Most common species here are – *Diplasium* sp., *Elatostema* ssp., *Pellionia* ssp., *Polystichum* sp., *Selaginella* sp. Sporadically observed species – *Alpinia* sp., *Goodyera schlechtendaliana*, *Ophiorrhiza* ssp., *Sonerila* ssp., *Tainia latifolia*, *Zingiber cochleariforme*, *Zingiber guangxiense* and *Zingiber recurvatum*.

Stratum of mosses and lichens (fifth forest stratum) of (0.1)0.5-3 cm tall covers ground on (10)30-80(100)%. It mainly includes mixture of indeterminable juvenile Bryophytes and lichens, as well as few tiny ferns, like *Trichomenes* sp. (Hymenophyllaceae) and species of cup lichens (*Cladonia* ssp., Cladoniaceae).

Non strata vegetation includes numerous epiphytes and lithophytes:

Dominant epiphytic species:

Bulbophyllum ambrosia, *Bulbophyllum reptans*, *Callostylis rigida*, *Ceratostylis himalaica*, *Coelogyne fimbriata*, *Davallia* sp., *Dendrobium spatella*, *Dischidia* sp., *Drynaria* sp., *Epigeneium amplum*, *Epigeneium chapaense*, *Eria pannea*, *Eria siamensis*, *Eria* ssp., *Eria thao*, *Lemmaphyllum microphyllum*, *Lepisorus* sp., *Microsorium* sp., *Pholidota articulata*, *Pholidota chinensis*, *Pholidota recurva*, *Pyrrosia* sp. and *Thelasis pygmaea*.

Associated epiphytic species:

Aeschynanthus mendumiae, *Aeschynanthus* ssp., *Bulbophyllum apodum*, *Bulbophyllum biesetoides*, *Bulbophyllum pecten-veneris*, *Bulbophyllum psychoon*, *Bulbophyllum* ssp.,

Cleisostoma striatum, *Cleisostoma williamsonii*, *Coelogyne* ssp., *Cymbidium* ssp., *Dendrobium brymerianum*, *Dendrobium chrysanthum*, *Dendrobium falconeri*, *Dendrobium fimbriatum*, *Dendrobium hancockii*, *Dendrobium nobile*, *Eria apertiflora*, *Hoya* sp., *Huperzia* sp., *Hygrochilus parishii*, *Liparis pumila*, *Liparis viridiflora*, *Luisia* ssp., *Luisia zollingeri*, *Lycopodium* sp., *Oberonia falconeri*, *Oberonia* ssp., *Ornithochilus difformis*, *Panisea* ssp., *Peperomia* sp., *Stereochilus brevirachis*, *Sunipia scariosa*, *Thrixspermum stelidioides*, *Trichotosia microphylla*, *Trichotosia pulvinata* and *Vanda* sp.

Dominant lithophytic species:

Asplenium rupestre, *Carex* sp., *Eria carinata*, *Eria globulifera*, *Eria siamensis*, *Flickingeria fimbriata*, *Liparis averyanoviana*, *Liparis viridiflora*, *Pyrrosia* ssp., *Vittaria hainanensis* and *Vittaria* sp.

Associated lithophytic species:

Antrophium sp., *Appendicula hexandra*, *Argostemma* ssp., *Asplenium* sp., *Boea* ssp., *Chirita* ssp., *Cymbidium lowianum*, *Didymocarpus* sp., *Eria bambusifolia*, *Eria calcarea*, *Eria corneri*, *Hedychium* sp., *Hedychium yunnanense*, *Hedyotis* ssp., *Lilium poilanei*, *Liparis superposita*, *Oreocharis argyrophylla*, *Oreocharis blepharophylla*, *Oreocharis* sp., *Paraboea* sp., *Peperomia* sp., *Rhynchotechum* sp., *Sonerila* ssp., *Streptocarpus* sp. and *Vittaria elongata*.

Woody and semi-woody lianas, like *Actinidia* sp., *Dioscorea* sp., *Smilax* sp. and *Tetrastigma* sp. may be occasionally found in coniferous forests, commonly on open rocky outcrops.

4. Evergreen broad-leaved tropical montane cloud forest (fig. 21; Appendix 1, 4)

Evergreen broad-leaved tropical montane cloud forest covers mountain tops and main summit of Pha Luong Mountains (fig. 21). Its fragments also may be seen on steep humid slopes and upper rocky cliffs (fig. 18) of any exposition at elevations (1500)1700-1860 m a.s.l. with inclination up to 90°. They grow on very thin, poor, well drained soils having brown, humus-containing horizon (0)5-10(15) cm derived from solid red-brown sandstone mother rocks. Leaf litter commonly – 0-3 cm thick, with projected coverage from 0 to 100% observed in small local depression. Vertical forest structure is simple and consists of only three strata.

First stratum includes mossy gnarled treelets and shrubs 2-5(8) m tall with (3)5-15(30) cm DBH forming canopy projective coverage (25)50-90(100)%. In chines, depressions or other wind protected places trees of these forests can reach 10-12 m tall, but in windy slopes the canopy stratum neither do nor exceeds 2-3 m tall. Main dominant here are such species as *Camellia* sp., *Castanopsis* ssp., *Gordonia* sp., *Ilex* sp., *Lithocarpus* ssp., *Quercus* ssp., *Rhododendron* ssp., *Schima wallichii* and *Viburnum* sp., with more or less usual associates like – *Cinnamomum* ssp., *Eriobotrya* sp., *Fokienia hodginsii*, *Gaultheria fragrantissima*, *Gaultheria* sp., *Leucothoe* sp., *Lithocarpus* ssp., *Litsea* ssp., *Lyonia ovalifolia*, *Lyonia* ssp., *Photinia cucphuongensis*, *Podocarpus neriifolius*, *Psychotria* ssp., *Rhododendron* ssp. and *Schefflera* sp.

Herbaceous stratum (second forest stratum) includes herbs 0.03-2 m tall with projective coverage (0)5-15(20)%. Main dominants here are – *Carex* sp., *Diplasium* sp., *Elatostema* ssp., *Pellionia* ssp., *Plagiogyria pycnophylla*, *Polystichum* sp., *Scleria* sp., *Selaginella* sp. As a more or less common associated species were observed – *Alpinia* sp., *Calanthe alleizettii*, *Calanthe puberula*, *Collabium chinense*, *Cymbidium ensifolium*, *Cymbidium kanran*, *Cymbidium lancifolium*, *Goodyera schlechtendaliana*, *Ophiorrhiza* ssp., *Sonerila* ssp., *Tainia latifolia*, *Zeuxine nervosa*, *Zingiber cochleariforme*, *Zingiber guangxiense* and *Zingiber recurvatum*.

Bryophytes and lichens (0.1)0.5-3 cm tall form third forest stratum covering (10)30-80(100)% of the forest floor. Mainly it includes mixture of juvenile mosses and lichens, as well as few tiny ferns – *Trichomenes* sp. (Hymenophyllaceae), cup lichens (*Cladonia* ssp., Cladoniaceae) and haircap mosses (*Polytrichum* ssp., Polytrichaceae).

Non strata vegetation includes many epiphytes and locally abundant lithophytes:

Dominant epiphytic species:

Bulbophyllum ambrosia, *Bulbophyllum reptans*, *Ceratostylis himalaica*, *Coelogyne fimbriata*, *Davallia* sp., *Epigeneium amplum*, *Epigeneium chapaense*, *Eria pannea*, *Eria siamensis*, *Eria* ssp., *Eria thao*, *Lepisorus* sp., *Microsorium* sp., *Pholidota articulata*, *Pholidota chinensis*, *Pholidota recurva*, *Pyrrosia* sp. and *Thelasis pygmaea*.

Associated epiphytic species:

Bulbophyllum pecten-veneris, *Bulbophyllum psychoon*, *Bulbophyllum* ssp., *Cleisostoma striatum*, *Cleisostoma williamsonii*, *Coelogyne* ssp., *Cymbidium* ssp., *Dendrobium nobile*, *Eria apertiflora*, *Huperzia* sp., *Liparis pumila*, *Liparis viridiflora*, *Luisia* ssp., *Luisia zollingeri*, *Lycopodium* sp., *Oberonia falconeri*, *Oberonia* ssp., *Ornithochilus difformis*, *Panisea* ssp., *Stereochilus brevirachis*, *Sunipia scariosa*, *Thrixspermum stelidioides*, *Trichotosia microphylla*, *Trichotosia pulvinata* and *Vanda* sp.

Dominant lithophytic species:

Asplenium rupestre, *Carex* sp., *Eria carinata*, *Eria globulifera*, *Eria siamensis*, *Flickingeria fimbriata*, *Liparis viridiflora* and *Pyrrosia* ssp.

Associated lithophytic species:

Appendicula hexandra, *Argostemma* ssp., *Asplenium* sp., *Boea* ssp., *Chirita* ssp., *Cymbidium lowianum*, *Didymocarpus* sp., *Eria bambusifolia*, *Hedychium* sp., *Hedychium yunnanense*, *Hedyotis* ssp., *Lilium poilanei*, *Oreocharis argyrophylla*, *Oreocharis blepharophylla*, *Oreocharis* sp., *Paraboea* sp. and *Vittaria elongata*.

Woody and semi-woody lianas are rather rare. Among them were observed *Dioscorea* sp., *Smilax* sp. and *Tetrastigma* sp.

5. Evergreen ericaceous montane scrub (fig. 23; Appendix 1, 5)

Ericaceous montane scrub covers highest rocky peaks of Pha Luong Mountains. These dense thickets observed on windy places of summits, on steep slopes and exposed cliffs at elevations (1500)1700-1860 m a.s.l. on any slope exposition at inclination 0-70(90)°. Mother rocks in these habitats are exclusively solid red-brown sandstone. Soils here are very thin, poor, well drained, with brown humus-containing horizon (0)1-3(5) cm thick. Ground surface covered by leaf litter 0-3 cm thick with projected coverage 0-100%. Vertical structure is very simple including actually only three strata.

First (woody) stratum of ericaceous scrub in Pha Luong Mountains includes small gnarled treelets and shrubs 1.5-2(3) m tall with trunks (1)3-10(15) cm in diameter. Projective coverage of this stratum is (30)40-90(100)%. Most common dominant species here are *Gaultheria fragrantissima*, *Gaultheria* sp., *Ilex* sp., *Leucothoe* sp., *Lyonia ovalifolia*, *Lyonia* ssp., *Rhododendron* ssp. and *Vaccinium* ssp. More or less common associates in this plant community are – *Eriobotrya* sp., *Fokienia hodginsii*, *Hypericum hookerianum*, *Lithocarpus* ssp., *Melastoma* sp., *Myrsine* sp., *Photinia cucphuongensis*, *Podocarpus neriifolius*, *Psychotria* ssp., *Quercus* sp., *Schefflera* sp. and *Viburnum* sp.

Herbaceous (second stratum) is not well pronounced having projective coverage not exceeding 10-15%. It includes scattered herbs 0.03-1(1.5) m tall. Few dominant species here are such species as *Carex* sp., *Diplasium* sp., *Elatostema* ssp., *Pellionia* ssp., *Polystichum* sp., *Scleria* sp., *Selaginella* sp. In addition, occasionally were also observed following associates – *Calanthe alleizettii*, *Collabium chinense*, *Cymbidium ensifolium*, *Cymbidium lancifolium*, *Goodyera schlechtendaliana*, *Sonerila* ssp., *Tainia* sp. and *Zeuxine nervosa*.

Moss and lichen stratum (0.1)0.5-3 cm tall has projective coverage (10)30-60(90)%. It includes mainly mixture of indeterminable juvenile species, as well as many cup lichens (*Cladonia* ssp., *Cladoniaceae*) and haircap mosses (*Polytrichum* ssp., *Polytrichaceae*).

Epiphytes here are not too common and numerous. Among them follow rather cool growing species were found – *Bulbophyllum ambrosia*, *Bulbophyllum psychoon*, *Bulbophyllum reptans*, *Bulbophyllum* ssp., *Ceratostylis himalaica*, *Cleisostoma williamsonii*, *Coelogyne* ssp.,

Davallia sp., *Dendrobium nobile*, *Epigeneium chapaense* (fig. 85, 86), *Huperzia* sp., *Lepisorus* sp., *Liparis viridiflora*, *Lycopodium* sp., *Microsorium* sp., *Pyrrosia* sp. and *Thelasis pygmaea*.

Lithophytes occasionally abundant, but their species diversity is less than at lower elevations. Most typical species here are – *Asplenium* sp., *Carex* sp., *Chirita* ssp., *Cymbidium lowianum*, *Eria bambusifolia*, *Eria carinata*, *Eria globulifera*, *Eria siamensis*, *Hedychium yunnanense* (fig. 87, 88), *Hedyotis* ssp., *Lilium poilanei* (fig. 89), *Liparis viridiflora* (fig. 77, 78), *Oreocharis argyrophylla* (fig. 68), *Oreocharis blepharophylla* (fig. 69), *Pyrrosia* ssp.

Among climbers and lianas may be mentioned – *Dioscorea* sp., *Smilax* sp. and *Tetrastigma* sp. occasionally found in rather open rocky places and cliffs.

6. Bamboo montane thickets (fig. 22; Appendix 1, 6)

Bamboo montane thickets are azonal plant community, which represents early successive stage of forest regeneration after forest fire. Meanwhile, this plant community remains more or less stable a long time on windy places, particularly on steep cliffy rocky outcrops or mountain tips (fig. 22). In Pha Luong Mountains bamboo montane thickets are common at elevation (1500)1700-1860 m on slopes of any exposition with inclination 0-70(90)°. They commonly cover mountain tops composed with red-brown sandstone. Leaf litter here 0-3 cm thick with projected coverage 0-100%. Soils are very thin, poor, well drained with brown humus-containing horizon commonly less than 5 cm thick. Structure of bamboo montane thickets in Pha Luong Mountains is very simple including three strata.

First stratum contains only one semi-woody species of indeterminable bamboo (*Arundinaria* aff.) with stems 1-2(2.5) m tall and 0.5-1(1.5) cm in diameter. It form rather dense thicket with projective coverage (25)50-80(100)%. Sparsely scattered associate shrubby species here are immature samples of *Eriobotrya* sp., *Gaultheria fragrantissima*, *Gaultheria* sp., *Ilex* sp., *Leucothoe* sp., *Lithocarpus* ssp., *Lyonia ovalifolia*, *Lyonia* ssp., *Myrsine* sp., *Photinia cucphuongensis* (fig. 74), *Podocarpus neriifolius*, *Psychotria* ssp., *Quercus* sp. (fig. 64), *Rhododendron* ssp., *Schefflera* sp., *Viburnum* sp.

Herbs are uncommon and sporadic. They form incomplete stratum 0.03-1 m tall with projective coverage (0)5-10(15)%. Recorded and documented species here are – *Calanthe alleizettii*, *Carex* sp., *Collabium chinense*, *Cymbidium ensifolium*, *Cymbidium lancifolium*, *Diplasium* sp., *Elatostema* ssp., *Goodyera schlechtendaliana*, *Polystichum* sp., *Scleria* sp., *Selaginella* sp., *Tainia* sp. and *Zeuxine nervosa*.

Mosses and lichens forms stratum (0.1)0.5-3 cm tall with ground coverage (10)20-40(60)%. It includes species of *Polytrichum* ssp. (Polytrichaceae) and numerous indeterminable juvenile Bryophytes and lichens.

Epiphytes and semi-epiphytes almost absent. Few recorded lithophytic species are – *Asplenium* sp., *Carex* sp., *Hedychium yunnanense* (fig. 87, 88), *Hedyotis* ssp., *Lilium poilanei* (fig. 89) and *Pyrrosia* ssp.

Among climbers and lianas were found species of *Dioscorea*, *Smilax* and *Tetrastigma*.

7. Sphagnum-herbaceous montane grasslands (fig. 24-27; Appendix 1, 7)

Montane grassy vegetation in Pha Luong Mountains is azonal plant community, which represents first initial successive stage of plant cover regeneration after forest fire. Mossy grasslands are well presented in main almost flat summit of Pha Luong Mountains at elevation 1800-1820 m a.s.l. Here on open sandstone rocky surface almost lacking of soil deposits this meadow-like plant community demonstrates certain stability in its structure and specific species composition. Only two strata may be recognized in this plant community.

Herbaceous stratum 0.03-1(1.5) m tall forming projective coverage (5)15-55(70)% includes following dominant species – *Carex* sp., *Cyperus* sp., *Hedychium yunnanense* (fig. 87, 88), *Hedychium* sp., *Melastoma* sp., *Scleria* sp., *Selaginella* sp., *Xyris indica*, *Xyris* sp. Many

other species occurring only in this specific habitat were documented here. Among them are – *Ainsliaea* sp., *Anemone* sp., *Anthogonium gracile*, *Blumea* sp., *Cyanotis* sp., *Drosera peltata*, *Hypericum hookerianum*, *Impatiens* sp., *Lilium poilanei* (fig. 89), *Lysimachia* sp., *Sedum* sp., *Strobilanthes taoana*, *Strobilanthes* sp. and *Clematis* sp. All these herbs grow here actually as true lithophytes.

Moss and lichen stratum (0.1)0.5-5(10) cm tall includes numerous indeterminable juvenile species of mosses and lichens, as well as species of *Cladonia* (Cladoniaceae), *Polytrichum* (Polytrichaceae) and *Sphagnum* (Sphagnaceae) with total projective coverage (10)30-50(100)%. *Sphagnum* pillows here reach often 10 cm tall and more than 1 m across. They form sometime miniature peat bogs in small depressions (fig. 25, 26), which provide home to many typical marshland species of such genera as – *Xyris*, *Cyperus*, *Drosera*, *Eriocaulon* etc.

Some climbers and lianas are more or less common here in open rocky outcrops and cliffs. Among such plants are species of such genera as *Ampelopsis*, *Crowfordtia*, *Dioscorea*, *Smilax* and *Tetrastigma*.

Non strata vegetation of Pha Luong Mountains

Epiphytic and lithophytic plants form specific extra-strata or non-strata plant communities, which belong to so-called non strata vegetation. Species composition of non-strata vegetation in Pha Luong Mountains is very rich due to relatively high humidity and numerous rocky outcrops, particularly in upper part of slopes.

Epiphytic plants are common in plant communities of Pha Luong Mountains at any elevations (fig. 65). Epiphytes here belong to many families, but ferns and orchids dominate in all habitats. Epiphytic species and their families are listed below.

Epiphytes more or less common in all kind of plant communities in Pha Luong Mountains

<u>Lycopodiaceae</u>	<i>Peperomia</i> sp.	<i>Dendrobium eriiflorum</i>	<i>Luisia zollingeri</i>
<i>Huperzia</i> sp.		<i>Dendrobium falconeri</i>	<i>Luisia</i> ssp.
<i>Lycopodium</i> sp.	<u>Orchidaceae</u>	<i>Dendrobium fimbriatum</i>	<i>Oberonia falconeri</i>
	<i>Bulbophyllum ambrosia</i>	<i>Dendrobium hancockii</i>	<i>Oberonia</i> ssp.
<u>Polypodiaceae s.l.</u>	<i>Bulbophyllum apodum</i>	<i>Dendrobium jenkinsii</i>	<i>Ornithochilus difformis</i>
<i>Davallia</i> sp.	<i>Bulbophyllum biesetoides</i>	<i>Dendrobium nobile</i>	<i>Panisea</i> ssp.
<i>Drynaria</i> sp.	<i>Bulbophyllum pecten-</i> <i>veneris</i>	<i>Dendrobium spatella</i>	<i>Pholidota articulata</i>
<i>Lemmaphyllum</i> <i>microphyllum</i>	<i>Bulbophyllum psychoon</i>	<i>Dendrobium thyrsoflorum</i>	<i>Pholidota chinensis</i>
<i>Lepisorus</i> sp.	<i>Bulbophyllum reptans</i>	<i>Epigeneium amplum</i>	<i>Pholidota recurva</i>
<i>Microsorium</i> sp.	<i>Bulbophyllum</i> ssp.	<i>Epigeneium chapaense</i>	<i>Smitinandia helferi</i>
<i>Pyrrosia</i> sp.	<i>Callostylis rigida</i>	<i>Eria apertiflora</i>	<i>Stereochilus brevirachis</i>
	<i>Ceratostylis himalaica</i>	<i>Eria calcarea</i>	<i>Sunipia scariosa</i>
<u>Asclepiadaceae</u>	<i>Cleisostoma striatum</i>	<i>Eria pannea</i>	<i>Tainia latifolia</i>
<i>Dischidia</i> sp.	<i>Cleisostoma williamsonii</i>	<i>Eria rhomboidalis</i>	<i>Thelasis pygmaea</i>
<i>Hoya</i> sp.	<i>Coelogyne fimbriata</i>	<i>Eria siamensis</i>	<i>Thrixspernum centipeda</i>
	<i>Coelogyne</i> ssp.	<i>Eria thao</i>	<i>Thrixspernum stelioides</i>
<u>Gesneriaceae</u>	<i>Cymbidium lowianum</i>	<i>Eria</i> ssp.	<i>Trichotosia microphylla</i>
<i>Aeschynanthus mendumiae</i>	<i>Cymbidium</i> ssp.	<i>Hygrochilus parishii</i>	<i>Trichotosia pulvinata</i>
<i>Aeschynanthus</i> ssp.	<i>Dendrobium brymerianum</i>	<i>Liparis longispica</i>	<i>Vanda</i> sp.
<i>Lysionotus chingii</i>	<i>Dendrobium chrysanthum</i>	<i>Liparis pumila</i>	
		<i>Liparis viridiflora</i>	

Lithophytic plant species are particularly common and even abundant in plant communities of Pha Luong Mountains at highest elevations (fig. 20) on slopes and cliffs allied to mountain tops. Lithophytes here belong to many families, but ferns, gesneriads and orchids dominate in all habitats. Lithophytic species and their families are listed below.

Lithophytes more or less common in all kind of plant communities

in Pha Luong Mountains

<u>Polypodiaceae s.l.</u>	Chirita ssp.	Peperomia sp.	Eria calcarea
Antrophium sp.	Didymocarpus sp.		Eria carinata
Asplenium antrophioides	Oreocharis argyrophylla	<u>Rubiaceae</u>	Eria corneri
Asplenium rupestre	Oreocharis blepharophylla	Argostemma ssp.	Eria globulifera
Asplenium sp.	Oreocharis sp.	Hedyotis ssp.	Eria rhomboidalis
Aglamorpha acuminata	Paraboea sp.		Eria siamensis
Vittaria elongata	Rhynchotechum sp.	<u>Zingiberaceae</u>	Flickingeria fimbriata
Vittaria hainanensis	Streptocarpus sp.	Hedychium yunnanense	Liparis averyanoviana
Vittaria sp.		Hedychium sp.	Liparis balansae
	<u>Liliaceae</u>		Liparis bootanensis
<u>Cyperaceae</u>	Lilium poilanei	<u>Orchidaceae</u>	Liparis dendrochiloides
Carex sp.		Appendicula hexandra	Liparis superposita
Scleria sp.	<u>Melastomataceae</u>	Collabium chapaensis	Liparis viridiflora
	Sonerila ssp.	Collabium chinense	
<u>Gesneriaceae</u>		Cymbidium lowianum	
Boea ssp.	<u>Piperaceae</u>	Eria bambusifolia	

HISTORY OF DISCOVERY AND TAXONOMY OF *PINUS CERNUA*

The history of *Pinus cernua* discovery was reported in details in earlier publications (Averyanov et al., 2014, 2015; Phan Ke Loc et al., 2014). The species was first recognized by Vietnamese geologists at the end of 2011 within the steep cliffs located in the peripheral zone of Pha Luong Mountains near Laos–Vietnam state boundary between Houaphan and Son La provinces. This discovery was announced in the January issue of the People’s Army Newspaper (Luong Tu Chan, 2012) and was also shortly noted in Vietnam Environment Administration Magazine (Le Tran Chan et al., 2012). In middle 2012 the discovery of the new species was confirmed by collected of voucher herbarium specimens (Nguyen Duc To Luu, 2013; Phan Van Thang et al., 2013). These initial assessments and attempts to understand newly discovered pine species resulted in its tentative identification as “*Pinus* aff. *armandii* Franchet” (Nguyen Duc To Luu et al., 2013; Phan Ke Loc et al., 2013). Meanwhile, authors indicated certain morphological differences found in the Vietnamese pine from true *P. armandii* (Phan Ke Loc et al., 2013). Almost simultaneously, the identification of the discovered plant as *P. fenzeliana* Hand.-Mazz., was proposed based on speculative studies of plant images entering to the Internet (Businsky, 2013). Further field and laboratory studies confirmed the obvious differences between the discovered plant from both *P. armandii* and *P. fenzeliana*, the latter known from isolated locations in southern China. Given the clear distinction of the discovered tree and its morphological differences from all known species of the genus, it was described as a new species under the name *Pinus cernua* L.K.Phan ex Aver., K.S.Nguyen et T.H.Nguyen in Averyanov et al. (2014, 2015). Other scientists also accepted the segregation of new taxon, but in subspecies rank. It resulted in description of the same pine under the name *Pinus armandii* Franchet subsp. *xuannhaensis* L.K.Phan (Phan Ke Loc et al., 2014a, b). This study based on extensive field investigations of many newly discovered subpopulations revealed fairly uniform morphology and very low genetic variability of new taxon (Nguyen Minh Tam, Phan Ke Loc, Vu Dinh Duy, 2015). At the same time, the another study based on observation of single marginal subpopulation of *Pinus cernua* (mixed with *P. latteri*) deny any differences of Pha Luong pine from internet-available herbarium specimens of *P. fenzeliana* originated from mainland SE. China and Hainan (Businsky, 2016). New field investigation and species assessment was undertaken throughout all area of Pha Luong Mountains in September – October 2016. It resulted in discovery of 6 new subpopulations of *Pinus cernua* in addition to already verified 16 earlier known localities. Extinction of one subpopulation due to forest burning is detected in south-east corner of the pine distribution area.

A detailed updated description and assessment of this rare highly endangered, locally endemic species is presented below.

Pinus cernua L.K.Phan ex Aver., K.S.Nguyen et T.H.Nguyen in Aver. et al., 2014, Nordic J. Bot. 32, 6: 792; Aver. et al., 2015, Turczaninowia 18, 1: 7.

= *P. fenzeliana* auct. non Hand.-Mazz.: Businsky, 2004, Willdenowia 34: 218; id., 2011, Phytion 51, 1: 84; id., 2013, ibid., 53, 2: 247, 257; id., 2016, Phytion 56, 2: 143, p.p.

= *P. armandii* auct. non Franch.: Nguyen Duc To Luu et al., 2013, Proc. 5th Nat. Sci. Conf. Ecol. Biol. Res. (Hanoi): 152; Phan Van Thang et al., 2013, Guide Conif. Hoa Binh, Son La prov.: 20; Phan Ke Loc et al., 2013, Ecol. Econ. J. 45: 42.

= *Pinus armandii* subsp. *xuannhaensis* L.K.Phan, 2014, Vietnam National University Journ. Sci. Nat. Sci. Technol. (Hanoi) 30, 3S: 54, fig. 2; id., 2014, Journ. Ecol. Econ. (Hanoi) 46: 72, fig. 2.

Non *Pinus fenzeliana* Hand.-Mazz. var. *annamiensis* Silba, 2000, Journ. Int. Conifer Preserv. Soc. 7: 30.

Non *Pinus fenzeliana* Hand.-Mazz. subsp. *annamiensis* (Silba) Silba, 2009, Journ. Int. Conifer Preserv. Soc. 16: 21 2009.

Described from the border region of northern Laos and Vietnam (“Laos-Vietnamese border between Son La and Houaphan provinces”).

Type. Vietnam, Son La province, Van Ho district, Chieng Xuan municipality, Co Hong village, territory of Xuan Nha Nature Reserve, NE. slopes of Pha Luong Mountains. Primary coniferous forest with *Pinus cernua* on very steep mountain slopes and cliffs composed of brown sandstone at elevations 1000–1050 m a.s.l., 20°42’14.2’’N, 104°43’53.9’’E, 12 November 2013, L. Averyanov et al. CPC 6992 (holotype – Herbarium of the Center for Plant Conservation!, isotype – LE!).

Tree (12)20–30(35) m tall, 0.4–0.8(1) m DBH. Canopy conical, becoming with irregularly rounded with age; branches suberect to pendulous; leafy branchlets gray-green, olive or yellow-brown, slightly glaucous, glabrous. Bark dull gray-brown to dark brown, roughly fissured into irregular polygonal flat or slightly concave plates, often resinous, inner bark reddish-brown, finely fibrous. Winter buds, orange-brown, often, cylindric, 1–2 cm long, 3–5 mm in diam.; scales narrowly triangular, (3)4–5 mm long, 1–2 mm wide at the base, acuminate, with slightly recurved scarious apex. Needles in fascicles of 5, (12)15–20(22) cm long, 0.6–0.8 mm thick, rich dark green, slender, cernuous, slightly twisted, serrulate, triangular in cross section, with 25–32 rigid erect denticles per cm along the each edge and with 3–4 stomatal lines on the ventral lateral surfaces; vascular bundle 1, large; resin ducts 3, subequal, medial and two lateral; the sheath early deciduous. Pollen cones numerous, in spiral clusters at the base of new shoots, ovoid, later elongate, suberect, more or less stout, 0.8–1.5 cm long, 6–8 mm in diam. Seed cones on stout peduncles 1–2 cm long, commonly clustering 2–6 in a whorl, rarely alone, erect, later facing in all directions, persistent for many years, brown to dark brown, ovoid, 8–11 cm long, 5–7 cm in diam., dehiscent at maturity, often profusely resinous. Seed scales woody, rigid, obovate-deltoid, 2.4–2.8(3) cm long, 1.5–2.5 cm wide, apophysis deltoid, recurved and thickened at apex in form of transversal finely grooved cushion, umbo insignificant, without mucro. Seeds dark brown, smooth, oblique obovoid, 1–1.2 cm long, 0.5–0.7 mm in diam., with rudimentary scarious thin wing 1–2 mm wide disintegrating to seed maturity and occasionally remaining in form of low irregular distal rim. Pollination February–March, seeds September–October.

Paratypes. Vietnam. Son La prov., Chieng Xuan (*N.D. Luu et al.* 2013): 4 Dec. 2012, *P.V. Thang et al.* 5 (VNU, PanNature Herbarium); 13 Dec. 2012, *N.D.T. Luu et al.* 24 (VNU, PanNature Herbarium); 16 Apr. 2013, *P.K.Loc et al.* P 11077; 16 Apr. 2013, P 11078-11080; 17 April 2013, P 11081-11082; 18 April 2013, 11084-11089 (LE, VNU, PanNature Herbarium).

Taxonomical notes. The discovered species probably has some relation to the variable complex of *Pinus fenzeliana* and *P. armandii*. Among a series of infraspecific taxa described in a

different rank and associated with the mentioned species, our plant may be closer to the Taiwanese *P. armandii* var. *mastersiana* (Hayata) Hayata with a very similar morphology of seed cones. At the same time our plant distinctly differs from this taxon in having slender narrow needles more than twice as long as the ripe seed cones (fig. 16-18), ovoid small persistent seed cones clustering regularly in whorls of 2–6, smaller seed scales with deltoid apophysis recurved and thickened at the apex in the form of a transverse, finely-grooved cushion without a distinct mucro and in seeds with a rudimentary, scarious, early-disintegrating wing. These characteristic features have already been emphasized during the initial studies of the first discovered subpopulations (Nguyen Duc To Luu et al., 2013, Phan Ke Loc et al., 2013) and in later studies (Phan Ke Loc et al., 2014a, b) resulted in description of *Pinus armandii* subsp. *xuannhaensis*. Specimens from Hainan selected as a neotype for *P. fenzeliana* do not agree with the species protologue (Businsky, 2004, 2011). They resemble Vietnamese plants and may be close to our species described here. At the same time according to its original description, *P. fenzeliana* has a distinct morphologic resemblance with the previously described *P. kwangtungensis* Chun ex Tsiang, or it may belong to a hybrid of uncertain origin. Some comments and individual opinions on *P. cernua* taxonomy may be additionally found in some relevant publication (Phan Ke Loc et al., 2014a; Businsky, 2016).

The name of the assessed pine, *P. cernua*, refers to the long slender weeping needles, which represent bright diagnostic feature easy distinguishing Pha Luong pine from more or less related species.

DISTRIBUTION, ECOLOGY AND POPULATION STRUCTURE OF *PINUS CERNUA*

Pinus cernua in Pha Luong Mountains is an integral element of evergreen mixed and coniferous tropical forests at elevation (800)850-1500(1550) m a.s.l. (fig. 16, 17; Appendix 1, 2 & 3). It is rather thermophile, warm-growing element in comparison with its more or less common coniferous associates like *Amentotaxus argotaenia*, *Amentotaxus yunnanensis*, *Cephalotaxus mannii*, *Cunninghamia konishii*, *Dacrycarpus imbricatus*, *Fokienia hodginsii* and *Podocarpus neriifolius*, which are occasionally observed at any elevations of Pha Luong mountain system (Phan Van Thang et al., 2013; Nguyen Minh Tam, Phan Ke Loc, Vu Dinh Duy, 2015). Whereas elevational distribution of *Pinus cernua* in studied mountains is strongly limited by 1500(1550) m a.s.l. In most localities, *Pinus cernua* is observed as a co-dominant or occasional associate in mixed forests with high percentage of broad-leaved trees. True mono- and oligodominant coniferous forests with *Pinus cernua* are rather rare and very limited in their territory. At elevations 1200-1550 m a.s.l. coniferous forests with *Pinus cernua* often mixed with *Fokienia hodginsii* (fig. 51, 55, 56). On lower elevations, at (800)850-1200 m a.s.l. *Pinus cernua* form monodominant coniferous forests, or sometimes sporadically mixed with scattered trees of *Pinus latteri* (Nguyen Minh Tam, Phan Ke Loc, Vu Dinh Duy, 2015; Businsky, 2016). Such species assemblage in its typical form was observed on few narrow highly dissected ridges of northern slopes in peripheral zone of Pha Luong mountains allied to agricultural fields (Businsky, 2016).

According to present knowledge, *Pinus cernua* is a local endemic of Pha Luong Mountains occurring on the Laos-Vietnamese state boundary between Houaphan and Son La provinces (fig 4-6). Deep erosion of the solid red-brown sandstones forms here unique picturesque landforms with numerous rocky ridges, very steep cliff slopes and rocky outcrops on the tops of remnant mesas (fig. 2-12). The species almost exclusively inhabits steep rocky slopes and cliffs composed with sandstone (fig. 38, 39, 49-51, 56) at elevation (800)850-1500(1550) m a.s.l. It was not found anywhere in Vietnam despite special extensive field searches.

Locations of all 22 presently extant and one extinct subpopulations are indicated (by appropriate numbers) on *Pinus cernua* distribution maps (figs. 28-31). Localities 1-12 discovered

during 2011-2013 listed also in table 2 were reported in earlier publications (Nguyen Duc To Luu et al., 2013; Averyanov et al., 2014, 2015).

Table 2.

Documented locations of *P. cernua* in Pha Luong Mountains reported in early publications (Nguyen Duc To Luu et al., 2013; Averyanov et al., 2014, 2015) presented on distribution maps (figs. 28-31).

Nº of location	POSITION	ELEVATION	VOUCHER SPECIMENS or/and PHOTOS
1	20°42'11"N, 104°41'04"E	949 m	<i>P.V. Thang et al. 5</i> , 4 Dec. 2012; <i>P.K. Loc et al. P 11077</i> , 16 Apr. 2013
2	20°42'07"N, 104°41'12"E	1000 m	<i>N.D.T. Luu et al. 24</i> , 13 Dec. 2012
3	20°42'10"N, 104°41'04"E	955 m	<i>P.K. Loc et al. P 11078, 11079, 11080</i> , 16 April 2013
4	20°42'07"N, 104°41'12"E	1000 m	<i>P.K. Loc et al. P 11081</i> , 17 April 2013
5	20°42'05"N, 104°41'08"E	1002 m	<i>P.K. Loc et al. P 11082</i> , 17 April 2013
6	20°42'13"N, 104°40'54"E	1010 m	<i>P.K. Loc et al. P 11084, 11085, 11086, 11087, 11088, 11089</i> , 18 April 2013
7	20°42'11.4"N, 104°40'53.4"E	1050 m	<i>Averyanov L. et al. CPC 6992</i> , 12 Nov. 2013
8	20°42'07.5"N, 104°40'41.7"E	1150 m	<i>Averyanov L. et N.S. Khang photos, CPC s.n.</i> , 12 Nov. 2013
9	20°41'39.4"N, 104°39'22.9"E	1400 m	<i>N.S. Khang photos, CPC s.n.</i> , 13 Nov. 2013
10	20°41'24.7"N, 104°39'13.8"E	1380 m	<i>N.S. Khang photos, CPC s.n.</i> , 13 Nov. 2013
11	20°41'31.0"N, 104°39'53.2"E	1450 m	<i>N.S. Khang photos, CPC s.n.</i> , 13 Nov. 2013
12	20°41'47.9"N, 104°39'45.6"E	1430 m	<i>N.S. Khang photos, CPC s.n.</i> , 13 Nov. 2013

Locations of 6 extant and 1 extinct subpopulations (numbered respectively as 13-18 and 19) discovered during our field works supported by Mohamed bin Zayed Species Conservation Fund in September – October 2016 are listed in table 3 and indicated on figs. 28-35.

Table 3.

Documented locations of *P. cernua* in Pha Luong Mountains discovered during fieldworks supported by Mohamed bin Zayed Species Conservation Fund in September – November 2016 presented on distribution map (figs. 28-31).

Nº of LOCATION	ADMINISTRATIVE POSITION	ELEVATION in m a.s.l.	POSITION	NUMBER of INDIVIDUALS	HEIGHT & DBH	DATE of OBSERVATION	COLLECTING Nº
13	Moc Chau distr., Chieng Son comm., Pha Luong village	1400-1500	20°41'33.2N 104°37'37.0E	2	15-20 m & 40-45 cm	22/09/2016	<i>CPC 7959</i>
14	Moc Chau Distr., Chieng Son comm., Pha Luong village	1350-1400	20°41'36.9N 104°37'47.6E; 20°41'37.9N 104°37'51.1E	20	10-15 m	23/09/2016	<i>CPC 8013</i>
15	Moc Chau Distr., Chieng Son comm., Pha Luong village	1350	20°41'36.4N 104°37'46.6E	6	8-10 m	24/09/2016	<i>CPC 8019</i>
16	Moc Chau Distr., Chieng Son comm., Pha Luong village	1425	20°41'30.9N 104°38'08.9E	3	10-12 m	25/09/2016	<i>CPC 8022</i>
17	Van Ho Distr., Tan Xuan comm., Bun village	1500-1550	20°40'58.4N 104°41'02.8E	20	10-15 m	27/09/2016	<i>CPC 8107</i>
18	Van Ho Distr., Tan Xuan comm., A Lay village	1500	20°40'46.2N 104°39'49.6E	3	15-20 m & 70-80 cm	01/10/2016	<i>CPC 8169</i>
19	Moc Chau distr.,	≈ 1500	≈ 20°40'27N	extinct	-	29/09/2016	-

	Chieng Son comm.		≈104°36'50E			
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Locations of 4 extant subpopulations (numbered respectively as 20-23) discovered 2015-2016 by other research groups and individuals (Nguyen Minh Tam et al., 2015; Businsky, 2016) are listed in table 4 and indicated on figs. 28-31.

Table 4.

Locations of *P. cernua* in Pha Luong Mountains reported in 2015-2016 by other sources (Nguyen Minh Tam et al., 2015; Businsky, 2016) presented on distribution map (figs. 28-31).

№ of LOCATION	ADMINISTRATIVE POSITION	ELEVATION in m a.s.l.	POSITION	NUMBER of INDIVIDUALS	HEIGHT & DBH	DATE of OBSERVATION	COLLECTING №
20	About 550 m to SW above Kho Hong village	800-1000	20°42'43"N 104°40'20"E	∞	to 20 m, to 0.8 m	14.03.2016	R.Businsky, no data.
21	Chieng Xuan commune ("Thac Nuoc" & "Gan VTV2" & "Dinh Pomu")	890-1050	20°42'N 104°40'E	≥71	no data	no data	no data
22	Chieng Xuan commune, "Dinh VTV2"	1410	20°41'40"N, 104°39'23"E	≥25	no data	no data	no data
23	Tan Xuan commune, "Tan Xuen"	1502	20°40'46"N, 104°39'46"E	≥21	no data	no data	no data

Actually, all discovered extant and extinct *Pinus cernua* subpopulations occupy total area less than 15 km² that spreads on 7.5 km from W to E (104°36'50E – 104°41'03E) and on 4.5 km from N to the S (20°40'27N – 20°42'43"N). At the same time, all locations are within 2 km of each other or less. Therefore, they may be reasonably regarded as lone population according to IUCN Red List criteria (IUCN Red List Categories and Criteria, 2001).

Mono- and oligodominant stands of *Pinus cernua* with more than 50-100 trees within locality are observed only in north-eastern part of distribution area (locations 1-8, 20, 21, figs. 28-31). Very few saplings and young immature trees (less than 1%) were observed in these subpopulations. Only 1 to 25 mature trees commonly scattered in broad-leaved forests were recorded in all other locations (9-18, 22, 23, figs. 28-31). One recently extinct subpopulation (19) was detected in south-western corner of the distribution area (figs. 28-31). Seedlings were not found in all observed locations. Burned, human-cut and naturally felled trunks were seen in some locations (fig. 57).

Newly found locations of *Pinus cernua* (numbered on figures as 13-18) discovered during fieldwork supported by Mohamed bin Zayed Species Conservation Fund in September – October expand known distribution area essentially (fig. 28 & 29).

Discovered locations 13-16 were found on rocky north-western offset of Pha Luong Mountains (fig. 2-4, 28, 29, 32, 33) at 20°41'30.9–20°41'37.9N and 104°37'37.0–104°38'08.9E. They form close group within 1 km² including each from 2 to 20 mature trees 8-20 m tall and (25)30-45 cm DBH (table 3). All trees grow here on very steep north faced slopes and cliffs in upper part on rocky eroded mesas often with association with *Fokienia hodginsii* (fig. 38-48) at elevations 1350-1500 m a.s.l. Discovered locations are situated here at distance 150-500 m from each other (fig. 32 & 33). No seedlings and saplings were found in these locations.

Discovered location 17 outlines south-eastern corner of *Pinus cernua* distribution at point 20°40'58.4N 104°41'02.8E (fig. 28 & 29, 34). This subpopulation includes 20 mature trees 10-15 m tall growing on rocky outcrops at elevation 1500-1550 m a.s.l. (table 3). This is highest elevation of known *Pinus cernua* habitats. Trees here inhabit upper parts of humid cliffy slopes of narrow ravines and canyons, as well as tops of remnant eroded mountaintops and mesas (fig. 49-52). *Fokienia hodginsii* is another common conifer at this location. No seedlings and saplings were observed here. Squirrels damaged many ripening cones in some trees in this location (fig. 54).

Newly found location 18 defines southern border of *Pinus cernua* distribution. It situated in point 20°40'46.2N 104°39'49.6E at elevation 1500 m a.s.l. (fig. 28, 29, 35). Only 3 old trees 15-20 m tall and 70-80 cm DBH, as well as few naturally fallen trunks were located in this subpopulation (fig. 57). Surviving *Pinus cernua* trees were observed here mostly on tops of remnant hills in association with *Fokienia hodginsii* (fig. 55 & 56). No young trees or seedlings were found in this locality.

Location of extinct subpopulation destroyed by forest fire 3-5 years ago was detected on the base of timber remnant and information obtained from local people. This locality is situated on Laos – Vietnam state border at elevation about 1500 m around point 20°40'27N 104°36'50E (fig. 28 & 29). Wide forest burning around this locality, as well as on all southern slopes of Pha Luong main summit (fig. 36 & 37) led to probably full extinction of *Pinus cernua* on Laos territory. The extinction of *Pinus cernua* due to extensive uncontrolled forest fires decreased its distribution area on at least 25% during last 5-15 years.

In its ecology, *Pinus cernua*, forms primary humid coniferous and mixed forests on steep slopes, cliffs and rocky outcrops of remnant, highly-eroded solid red-brown sandstone at elevations (800)8500–1500(1550) m a.s.l. Often it was observed also as a scattered tree in closed evergreen, broad-leaved forests. Its occasional gymnosperm associates are *Amentotaxus argotaenia*, *Amentotaxus yunnanensis*, *Cephalotaxus mannii*, *Cunninghamia konishii*, *Dacrycarpus imbricatus*, *Fokienia hodginsii* and *Podocarpus neriifolius*. Habitat character, plant community structure and common associates are described above under characteristics of evergreen mixed tropical submontane forest (Appendix 1, 2) and evergreen coniferous tropical submontane forest (fig. 16, 17; Appendix 1, 3) listed in accepted classification as II.A.2a formation – Evergreen needle-leaves woodland composed of trees at least 15 m tall with crown coverage more than 40% (UNESCO, International classification ..., 1973).

Seed cones in most subpopulations develop high percentage of mutilated abnormal or abortive seeds (fig. 92-94), or no seed at all. At the same time, squirrels and other rodents eat almost all normally developed seeds in ripening cones (fig. 54). This is serious factor preventing successful natural seed propagation. Seed fertility of *P. cernua* varies between 50–60% according to observations on germination of seeds collected during autumn of 2013 and 2016 (Averyanov et al., 2015a). It was observed that most seedlings in nature die soon after germination (Phan Ke Loc et al., 2013). Meanwhile, seedlings demonstrate good growth and development under cultivation *ex situ* at least during first year age (Averyanov et al., 2015a).

Very few saplings are found on open rocky slopes and cliff shelves only in a several location in south-east corner of *Pinus cernua* distribution. In shady forests on mountain summits regeneration is very poor or absent. Data are available regarding the successful cultivation by seeds and cuttings (Nguyen Duc To Luu, 2013; Phan Van Thang et al., 2013; Averyanov et al., 2015a). In natural habitats trees grow rather slow. Winter buds form new leaves in March – April. Male strobili spread pollen for pollination in February – early April. Seeds ripening in 20-22 months later, in October – December (Phan Ke Loc et al., 2014a, b). Annual growth of individual trees of *P. cernua* in observed populations is very variable and depends on habitat conditions. Timber of plants found on relatively dry open rocky summits exhibits annual rings (0.3)0.5–1(1.5) mm wide, which indirectly estimates the age of the oldest observed trees of between 150–200 years.

CONSERVATION ASSESSMENT OF *PINUS CERNUA*

Previous assessments of *Pinus cernua* conservation IUCN Red List status according to standard categories and criteria based on available knowledge were undertaken in a series of earlier publication (Averyanov et al., 2014, 2015; Phan Ke Loc et al., 2014a, b; Nguyen Minh Tam et al., 2015). In these publications the preliminary status of this species was assessed as undoubtedly critically endangered (CR) under criteria “A4cd, B1b(iii), B2b(iii, iv, v), C1” (Phan

Ke Loc e al., 2014a, b), “B1ab(i, iii), B2ab(iii), C1, C2a(ii)” (Averyanov et al., 2014, 2015) and “B1ab (iii,iv)” (Thomas, 2015).

The review of all earlier data and results of present field studies confirm current global status of *Pinus cernua* as a critically endangered species according to following formal IUCN Red List criteria.

A. Population reduction

Actual present day data: reduction of species distribution area on 25-30% during last 3-5 years approximately from 20 to 15 km² (fig. 28 & 29) and on at least 30-40% during 5-15 past years.

Present actual species conditions match with following criteria:

A2. Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible: - **≥ 30%**

(a) direct observation

(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality

(d) actual or potential levels of exploitation

A3. Population reduction projected or suspected to be met in the future (up to a maximum of 100 years): - **≥ 30%**

(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality

(d) actual or potential levels of exploitation

A4. An observed, estimated, inferred, projected or suspected population reduction (up to a maximum of 100 years) where the time period must include both the past and the future, and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible; - **≥ 30%**

(c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality

(d) actual or potential levels of exploitation

Status according to formal criteria A: A2a,c,d, A3c,d, A4c,d = **VU**

B. Geographic range

Actual present day data: present species distribution area (extent of occurrence – EOO) is less than 15 km² (fig. 28 & 29); present species occupancy area (AOO) is less than 3 km²; 22 localities are currently known but these are within 2-3 km of each other and may be regarded as a single known population with close species locations.

Present actual species conditions match with following criteria:

B1. Extent of occurrence (EOO): - **< 100 km²**

(a) Severely fragmented, (b) Continuing decline in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals.

B2. Area of occupancy (AOO): - **< 10 km²**

(a) Severely fragmented, (b) Continuing decline in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals.

Status according to formal criteria B: B1a,b(i-v), B2a,b(i-v) = **CR**

C. Small population size and decline

Actual present day data: number of mature individuals more than 250, but less than 2500, affected undoubtedly by decreasing on 20% during 2 generations; 1 population is known, consisting of about 95% mature individuals.

Present actual species conditions match with following criteria:

Number of mature individuals - < **2,500**

C1. An estimated continuing decline of at least - **20% in 2 generations**

C2. An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions: a i - number of mature individuals in each subpopulation ≤ 250 ; a ii - % of mature individuals in one subpopulation = **95–100%**

Status according to formal criteria C: C1, C2a(i,ii) = **EN**

D. Very small or restricted population

Actual present day data: AOO less than 3 km².

Present actual species conditions match with following criteria:

D2. Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time, - **AOO < 20 km²**

Status according to formal criteria D: D2 = **VU**

E. Quantitative Analysis

Actual present day data: AOO less than 3 km².

Present actual species conditions match with following criteria:

Indicating the probability of extinction in the wild to be: - **$\geq 20\%$ in 20 years or 5 generations (100 years max.)**

Status according to formal criteria EC: E = **EN**

The status of *Pinus cernua* based on assessment data according to various formal IUCN Red List criteria (A-E) are follow:

A2(a, c, d), A3c, d), A4(c, d) – VU

B1(a, b i-v), B2(a, b i-v) – CR

C1; C2(a i, ii) – EN

D2 – VU

E – EN

Following to the highest rank of the accepted status category of *Pinus cernua* should be respectively assessed as globally critically endangered species (CR) according to IUCN Red List criteria and categories (IUCN Red List Categories and Criteria, 2001).

The habitat loss caused by occasional uncontrolled forest fires connected with primitive agriculture is the main fatal factor of *Pinus cernua* extinction. Additional, but also important damage factors are deforestation caused by forest logging, selected felling for fragrant soft pine timber, over-exploitation by local people and forestry enterprises, clearing forest for agriculture fields, as well as miserable area of actual occupancy, seed mutilation (fig. 54, 92-94) and very poor regeneration. Anthropogenic pressure over many years has resulted in a great fragmentation of surviving coniferous forests with *Pinus cernua* and led to deep their degradation in most of habitats. Presently *Pinus cernua* often survives only in small patches of secondary forests surrounded by agricultural fields. Some of known subpopulations are situated outside Xuan Nha Natural Reserve on lands having no any protected status.

Protection and monitoring of all known subpopulations of *Pinus cernua* located within and outside the Xuan Nha Nature Reserve may be living important action for the species effective conservation. The including of newly discovered locations into proper Xuan Nha Nature Reserve territory or into its buffer zone may be well step on this way. The studies of seed biology and germination, as well as artificial seed propagation, plantation and reforestation may seriously support species conservation. The attempts of the initiation of a community based conservation programme that involves seed collecting, cultivation and reintroduction for the reinforcement of existing stands may be very fruitful initiative (Phan Van Thang et al., 2013;

Nguyen Duc To Luu, 2014; Averyanov et al., 2015a). Mature samples of *Pinus cernua* forms nodding shoots with long slender weeping needles and is highly desirable for cultivation as ornamental tree, particularly in rock gardens of the Asian style. Ex-situ propagation and introduction into cultivation of this species as an ornamental plant may be additional effective measures to its conservation. More surveys on mountainous boundary areas in Vietnam and particularly in the Lao PDR should be undertaken as soon as possible for searches of more possibly surviving populations.

PLANT DIVERSITY AND FLORA OF PHA LUONG MOUNTAINS

Flora of Pha Luong Mountains belongs to typical tropical floras of North Indochinese floristic province of Indochinese floristic region belonging to Indomalaysian subkingdom of Holarctic (Averyanov et al., 2003). It contains many representatives of true tropical families such as Acanthaceae, Anacardiaceae, Annonaceae, Apocynaceae, Balanophoraceae, Begoniaceae, Burmanniaceae, Gesneriaceae, Melastomataceae, Meliaceae, Rubiaceae, Sapindaceae, Sapotaceae, Simaroubaceae and Zingiberaceae. Largest family here like in all other tropical floras is orchids – Orchidaceae. Meanwhile, subtropical Holarctic plant representatives participate and even dominate in plant communities at elevation higher 1200-1500 m. They are representatives of families like Aceraceae, Betulaceae, Cornaceae, Cupressaceae (fig. 61, 62), Cyperaceae, Ericaceae, Fagaceae (fig. 64), Hamamelidaceae, Magnoliaceae (fig. 63), Pinaceae, Polygonaceae, Primulaceae, Ranunculaceae, Rosaceae and Taxaceae, as well as subtropical ferns and fern of moderate climate (*Adiantum*, *Asplenium*, *Diplazium*, *Polystichum*, *Thelypteris* etc.). The combination of different geographic elements makes diversity and richness of the flora of Pha Luong Mountains particularly high and diverse.

At least 1131 plant species belonging to 650 genera and 189 families were reported recently in Xuan Nha Nature Reserve including western part of Pha Luong Mountains (Tran Huy Thai, 2012). Among them are 33 rare threatened species recorded in the Red Data Book of Vietnam, 356 woody species, 400 medicinal and 90 essential oil plants, as well as 180 other species used in national economy including oleiferous, tannin-bearing, fibre, edible and ornamental plants.

During fieldwork for conservation assessment of *Pinus cernua* were collected at least, 550 species of vascular plants belonging to 180 genera and 99 families listed in Appendix 2. For all these species were prepared voucher herbarium specimens as a scientific base for habitat and plant community descriptions (Appendix 1). Voucher herbaria are presently housed at Herbaria of Komarov Botanical Institute of the Russian Academy of Sciences in St.-Petersburg (LE) and in The Center for Plant Conservation of Vietnam Union of Science and Technology Associations in Hanoi. Among 10 largest families in preliminary assessed flora of Pha Luong Mountains are Orchidaceae (130 species), Polypodiaceae s.l. (55 spp.), Gesneriaceae (30 spp.), Rubiaceae (27 spp.), Convallariaceae (26 spp.), Ericaceae (21 spp.), Melastomataceae (14 spp.), Begoniaceae (11 spp.), Acanthaceae (10 spp.) and Magnoliaceae (9 spp.).

Among collected plants, 6 species are discovered as a new species for the flora of Vietnam. Firstly recorded in the country are – *Calanthe puberula* Lindl. (fig. 81, 82), *Cymbidium kanran* Makino, *Hoya lyi* H.Lev., *Ophiopogon bockianus* Diels, *Phylacium majus* Collett & Hemsl., *Smitinandia helferi* (Hook.f.) Garay and *Stereochilus brevirachis* Christenson (Appendix 2).

At least 30 species detected here and confirmed by voucher herbaria are threatened local endemics desirable for special protection on national level (Appendix 2). They are:

Anoectochilus annamensis Aver.
Bulbophyllum violaceolabellum Seidenf.
Calanthe alleizettii Gagnep.

Calocedrus rupestris Aver. et al.
Collabium chapaensis (Gagnep.) Seidenf. &
Ormerod

<i>Cycas collina</i> K.D.Hill et al.	<i>Liparis pumila</i> Aver.
<i>Diplopanax vietnamensis</i> Aver. & T.H.Nguyen (fig. 60)	<i>Liparis superposita</i> Ormerod
<i>Epigeneium chapaense</i> Gagnep. (fig. 85, 86)	<i>Lysionotus chingii</i> Chun ex W.T.Wang (fig. 83, 84)
<i>Eria calcarea</i> V.N.Long & Aver.	<i>Photinia cucphuongensis</i> T.H.Nguyen & Yakovlev (fig. 74)
<i>Eria pachyphylla</i> Aver.	<i>Pinus cernua</i> Aver. et al.
<i>Eria thao</i> Gagnep.	<i>Podochilus oxystophylloides</i> Ormerod.
<i>Eriodes barbata</i> (Lindl.) Rolfe	<i>Rhomboda petelotii</i> (Gagnep.) Ormerod
<i>Habenaria medioflexa</i> Turrill	<i>Spatholirion puluongense</i> Aver. (fig. 75, 76)
<i>Hedychium yunnanense</i> Gagnep. (fig. 87, 88)	<i>Thrixspermum stelidioides</i> Aver. et Averyanova
<i>Lecanorchis vietnamica</i> Aver.	<i>Trachycarpus geminisectus</i> Spanner & al.
<i>Lilium poilanei</i> Gagnep. (fig. 89)	<i>Trevesia vietnamensis</i> J.Wen & P.K.Loc
<i>Liparis averyanoviana</i> Szlach.	
<i>Liparis balansae</i> Gagnep. (fig. 77, 78)	
<i>Liparis dendrochiloides</i> Aver.	

About 12 plant species found in Pha Luong Mountain and in closely allied territories are appeared as a new for science (Appendix 2). Among them 5 species are described in recent publications (Vislobokov et al., 2014; Averyanov et al., 2015b, 2016a, b). These species are – *Aspidistra nutans* Aver. & Tillich (fig. 66, 67), *Liparis longispica* Aver. et K.S.Nguyen, *Ophiopogon alatus* Aver. & N.Tanaka, *Peliosanthes kenhilloides* Aver. et N.Tanaka and *Tupistra khangii* Aver. et al. Four species are presently submitted for publication. They are – *Aspidistra bifolia* Aver., Tillich & K.S.Nguyen (fig. 70, 71, 95), *Gastrodia khangii* Aver. (fig. 72, 73, 96), *Oreocharis argyrophylla* W.H.Chen et al. (fig. 68) and *Oreocharis blepharophylla* W.H.Chen et al. (fig. 69). Three species – *Aspidistra ambigua* sp. nov., CPC 8167, *Begonia phaluongense* sp. nov., CPC 7962 and *Phyllagathis pulchella* sp. nov., CPC 7910 (fig. 79, 80) are proposed for description as a new species for science in coming future. A number of endemic or sub-endemic plant species native to Pha Luong Mountains and allied lands have large significance as ornamental plants desirable for cultivation and breeding. Among them many species of such families as Arecaceae, Begoniaceae, Convallariaceae, Cupressaceae (fig. 61, 62), Ericaceae, Gesneriaceae (fig. 90, 91), Liliaceae (fig. 98), Magnoliaceae (fig. 63), Orchidaceae, Pinaceae (fig. 38-53), Podocarpaceae, Theaceae and Zingiberaceae (fig. 87, 88), etc.

Selected scenes of fieldworks for *Pinus cernua* conservation assessment supported Mohamed bin Zayed Species Conservation Fund during September – October 2016 are presented on figures 97-115.

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ILLUSTRATIONS

NOTES TO ILLUSTRATIONS

Pha Luong Mountains basic geomorphology

1. Pha Luong Mountains, view from the north.
2. Main Pha Luong summit, NNW slope.
3. Eastern Peak of Pha Luong Mountains, N slope
4. NE slopes of Pha Luong Mountains
5. Main Pha Luong summit, SEE slope.

Main landforms of Pha Luong Mountains

6. Sandstone cliffs in central part of Pha Luong Mountains
7. Remnant relictual highly eroded sandstone mesas in central part of Pha Luong Mountains
- 8-9. Open sandstone cliffs typical for Pha Luong Mountains
- 10-11. Highly eroded sandstone boulders, rocks and caves typical for rocky landscape of Pha Luong Mountains
12. Typical outcrops of red-brown sandstone, which are main mother rocks of Pha Luong Mountains

Main types of plant communities in Pha Luong Mountains

13. Primary evergreen broad-leaved forest (NNE slope of Pha Luong Mountains at 700-1500 m a.s.l.)
14. Primary evergreen broad-leaved forest (SEE slope of Pha Luong Mountains at 700-900 m a.s.l.)
15. Primary evergreen broad-leaved forest on rocky ridges (E slopes of Pha Luong Mountains at 800-1200 m a.s.l.)
16. Primary evergreen coniferous forest with *Fokienia hodginsii* on tops of ridges and mesas (central part of Pha Luong Mountains at 1400-1500 m a.s.l.)
17. Primary evergreen coniferous forest with *Pinus cernua* on tops of ridges and mesas (central part of Pha Luong Mountains at 1400-1500 m a.s.l.)
- 18-19. Primary evergreen broad-leaved forest on upper part of mountain slopes and cliffs (central part of Pha Luong Mountains at 1500-1600 m a.s.l.)
20. Azonal lithophytic vegetation near main Pha Luong summit (about 1800 m a.s.l.)
21. Primary evergreen broad-leaved cloud forest near Pha Luong peak (about 1850 m a.s.l.)
22. Bamboo (*Arundinaria* aff.) wind-formed thickets on exposed rocky outcrops near Pha Luong peak (about 1800 m a.s.l.)
23. Ericaceous wind-formed thickets on exposed rocky outcrops near Pha Luong peak (about 1850 m a.s.l.)
- 24-26. Secondary mossy sphagnum-herbaceous grasslands on flat rocks cleaned by fire (Pha Luong summit, 1800-1840 m a.s.l.)
27. Secondary grassy-sedge-herbaceous grassland on rocky outcrops on W cliff of Pha Luong summit (1800-1810 m a.s.l.)

Mapping and distribution of *Pinus cernua* in Pha Luong Mountains

28. Map of Pha Luong Mountains and allied regions with indication of *Pinus cernua* localities

Legend:

- Green line – Maximal suitable area of possible *Pinus cernua* occurrence (less than 74 km²)
- Pink-shaded area – Maximal suitable area of possible *Pinus cernua* occupancy (less than 25 km²)
- Red and black dots – Documented existing subpopulations (1-18, 20-23)
- Black cross – Location of extinct subpopulation (19)

29. Former and present distribution of *Pinus cernua* in Pha Luong Mountains

Legend:

- Polygon marked with dash and entire lines designates former occurrence area of *Pinus cernua* (≈20 km², for about year 2010)
- Polygon marked with entire line designates present actual occurrence area of *Pinus cernua* (≈15 km², for the year 2016)
- Red and black dots indicate positions of presently existing subpopulations: 1-12 – locations discovered in 2013-2015 (Averyanov et al., 2015); 13-18 – locations discovered by our research group in current study in September - October 2016; 20-23 – locations discovered by other researchers in 2015-2016 (Nguyen Minh Tam et al., 2015; Businsky, 2016, pers. comm.)

Black cross indicate location of extinct population (19) detected by our research group in current study in September - October 2016

Estimated present actual occupancy area for the year 2016 less than 5 km²

30. Landscape satellite image of Pha Luong Mountains with indication of all existing and one extinct *Pinus cernua* subpopulations

Legend:

Red and black dots indicate positions of presently existing subpopulations: 1-12 – locations discovered in 2013-2015 (Averyanov et al., 2015); 13-18 – locations discovered by our research group in current study in September - October 2016; 20-23 – locations discovered by other researchers in 2015-2016 (Nguyen Minh Tam et al., 2015; Businsky, 2016, pers. comm.)

Black cross indicate location of extinct population (19) detected by our research group in current study in September - October 2016

31. Landscape satellite image of Pha Luong Mountains (N slopes, view from the angle 45°) with indication of all existing (1-18, 20-23) and one extinct (19) *Pinus cernua* subpopulations.
32. Landscape satellite image of the NEE part of Pha Luong Mountains (view from S at the angle 45°) with indication of *Pinus cernua* subpopulations 13-16 discovered by our research group in current study in September - October 2016
33. Landscape satellite image of the NEE part of Pha Luong Mountains (view from N at the angle 45°) with indication of *Pinus cernua* subpopulations 13-16 discovered by our research group in current study in September - October 2016
34. Landscape satellite image of the SE part of Pha Luong Mountains (view from SSE at the angle 30°) with indication of *Pinus cernua* subpopulation 17 discovered by our research group in current study in September - October 2016
35. Landscape satellite image of the southern part of Pha Luong Mountains (view from S at the angle 30°) with indication of *Pinus cernua* subpopulation 18 discovered by our research group in current study in September - October 2016
- 36-37. Landscape satellite image of southern slopes of Pha Luong Mountains with vast burned areas in Laos territory where *Pinus cernua* extinct completely (yellow line demarcates border between Laos and Vietnam). Photo of 4.04.2015

Documentary photos of newly discovered *Pinus cernua* subpopulations in Pha Luong Mountains

- 38-42. Landscape and *Pinus cernua* trees in locality of discovered subpopulation № 13 (voucher herbarium collecting number CPC 7959)
- 43-45. Native photos of *Pinus cernua* specimens in discovered subpopulation № 14 (voucher herbarium collecting number CPC 8013)
46. Typical tree of *Pinus cernua* in discovered subpopulation № 15 (voucher herbarium collecting number CPC 8019)
- 47, 48. Typical trees of *Pinus cernua* in discovered subpopulation № 16 (voucher herbarium collecting number CPC 8022)
- 49-52. Landscape, character of the forest and *Pinus cernua* trees in locality of discovered subpopulation № 17 (voucher herbarium collecting number CPC 8107)
- 53, 54. Intact ripening female cones and cones damaged by squirrels observed in subpopulation of *Pinus cernua* № 17 (voucher herbarium collecting number CPC 8107)
- 55, 56. Landscape, character of the forest and *Pinus cernua* trees in locality of discovered subpopulation № 18 (voucher herbarium collecting number CPC 8169)
57. Logged mature tree trunk of *Pinus cernua* in locality of discovered subpopulation № 18

Typical plants and important co-dominants in mixed coniferous forest with *Pinus cernua* in Pha Luong Mountains

- 58, 59. Co-dominant of first stratum of evergreen broad-leaved forest – *Parakmeria robusta* (B.L.Chen & Noot.) Q.N.Vu & N.H.Xia (CPC 7961 photos)
60. Co-dominant of first stratum of evergreen broad-leaved forest – *Diplopanax vietnamensis* Aver. & T.H.Nguyen (ass. with CPC 7961 photos)
- 61, 62. Co-dominant of first stratum of evergreen coniferous forest – *Fokienia hodginsii* (Dunn) A.Henry & H.H.Thomas (CPC 7032, CPC 7929, CPC 8014, CPC 8018 photos, CPC 8174)
63. Co-dominant of first stratum of evergreen broad-leaved forest – *Magnolia megaphylla* (Hu & W.C.Cheng) V.S.Kumar (CPC 7920, CPC 8132 photos)
64. Co-dominant of first stratum of evergreen broad-leaved forest – *Quercus* sp. (CPC 7927 photos)

65. Typical epiphytic communities in middle part of Pha Luong Mountain slopes presented mainly by *Asplenium nidus* (ass. with CPC 8181 photos)

New species for science discovered in Pha Luong Mountains and allied areas

- 66, 67. *Aspidistra nutans* Aver. & Tillich (CPC 7158a, CPC 8155, CPC 7912 photos)
68. *Oreocharis argyrophylla* W.H.Chen et al. (CPC 7020, CPC 7175, CPC 7939, CPC 7993, CPC 8173 photos)
69. *Oreocharis blepharophylla* W.H.Chen et al. (CPC 7019 CPC 8000, CPC 8171 photos)
70, 71. *Aspidistra bifolia* Aver., Tillich & K.S.Nguyen, sp. nov. (CPC 8057 photos)
72, 73. *Gastrodia khangii* Aver., sp. nov. (CPC 8240 photos)

Endemic species discovered in Pha Luong Mountains and allied areas desirable for special protection

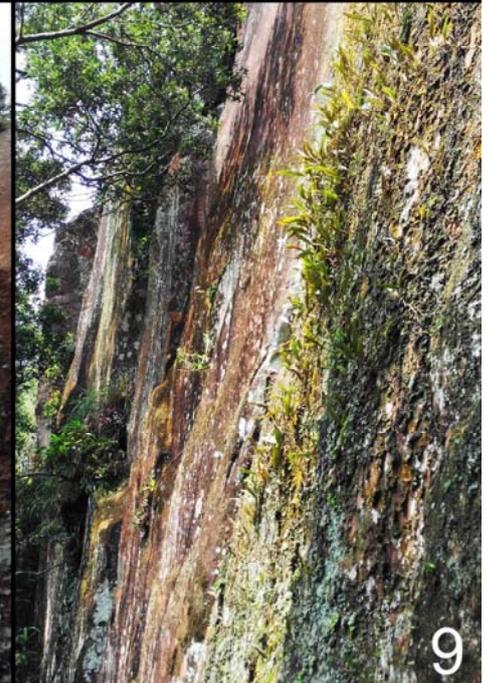
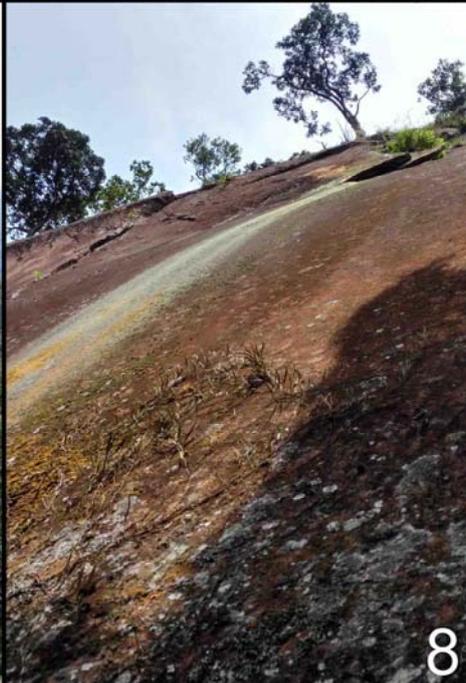
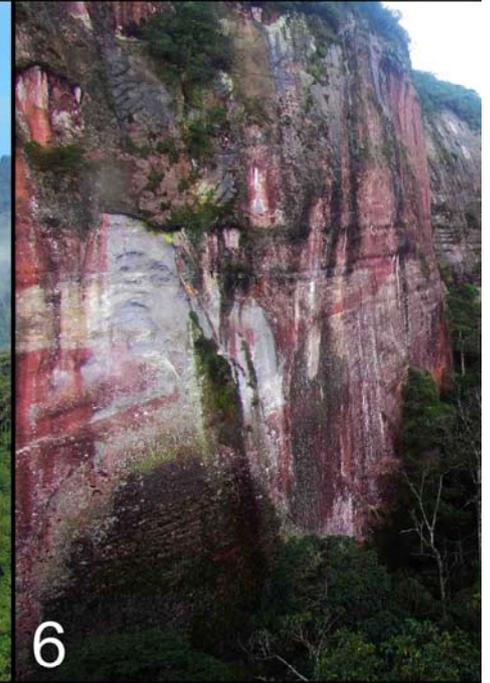
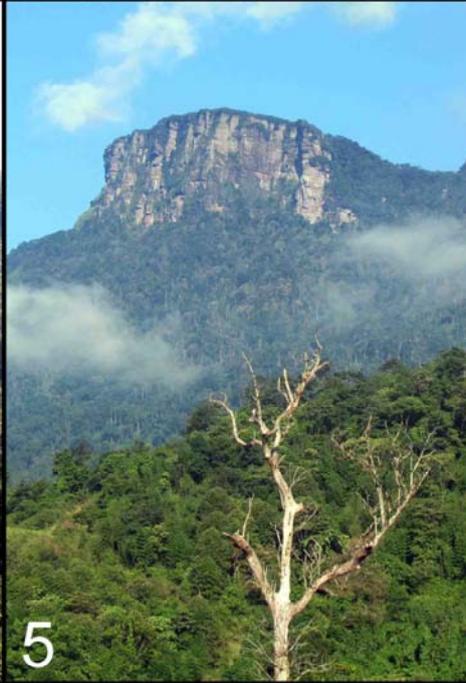
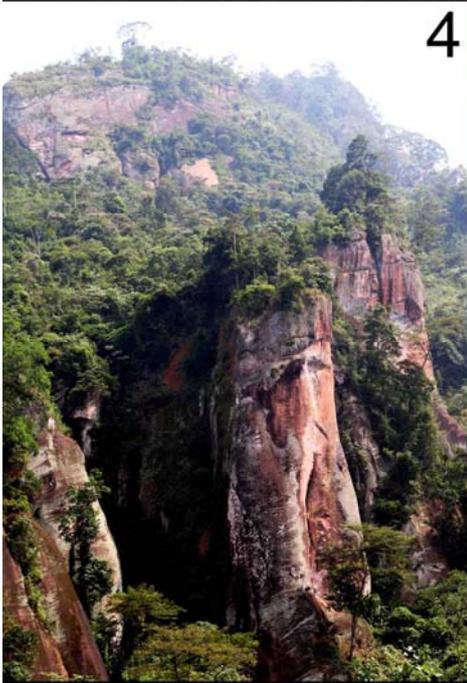
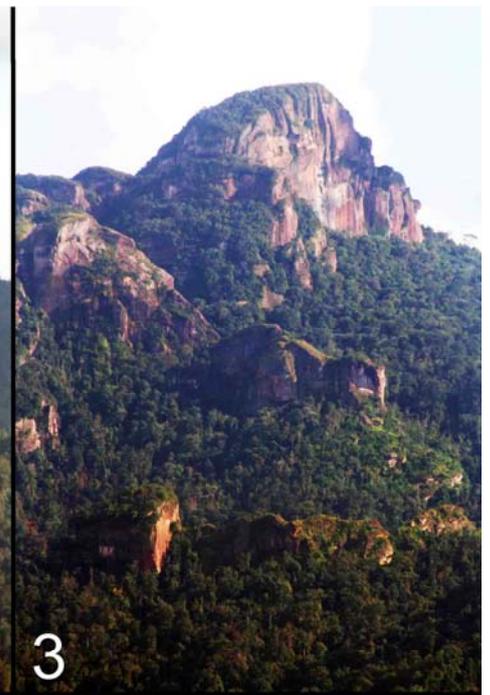
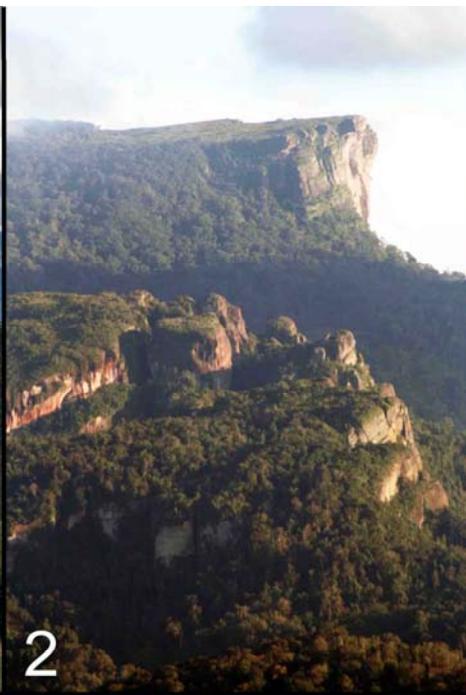
74. *Photinia cucphuongensis* T.H.Nguyen & Yakovlev (CPC 7932 photos)
75, 76. *Spatholirion puluongense* Aver. (CPC 7918 photos)
77, 78. *Liparis balansae* Gagnep. (CPC 8009, CPC 8017 photos)
79, 80. *Phyllagathis pulchella* sp. nov.? (CPC 7910 photos)
81, 82. *Calanthe puberula* Lindl. (CPC 7999 photos)
83, 84. *Lysionotus chingii* Chun ex W.T.Wang (CPC 8156 photos)
85, 86. *Epigeneium chapaense* Gagnep. (CPC 7025, CPC 7957, CPC 8143, CPC 8232 photos)
87, 88. *Hedychium yunnanense* Gagnep. (CPC 7949, CPC 7968 photos)
89. *Lilium poilanei* Gagnep. (CPC 7978, CPC 8216 photos)
90, 91. *Calcareoboea coccinea* C.Y.Wu (CPC 8235 photos.)

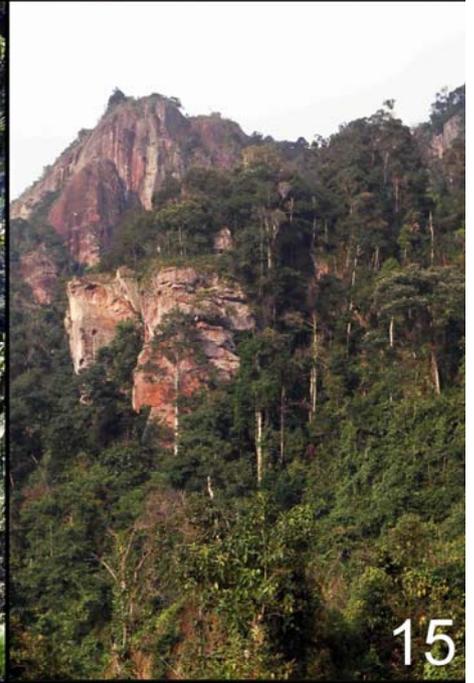
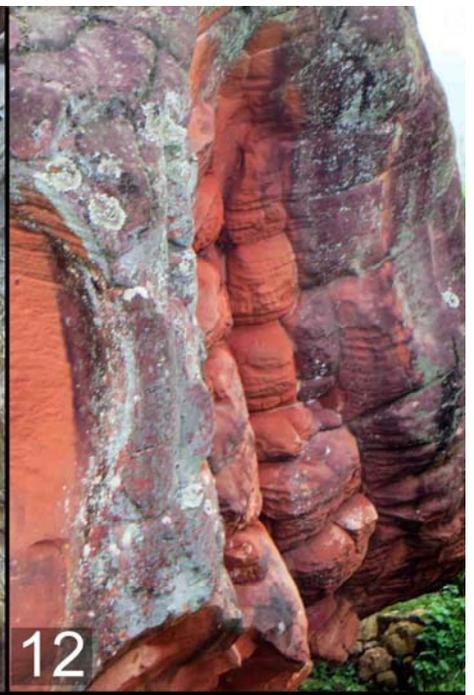
Examples of digital herbarium specimens of most important collections

92. *Pinus cernua* Aver. et al. CPC 8013
93. *Pinus cernua* Aver. et al. CPC 8019
94. *Pinus cernua* Aver. et al. CPC 8107
95. *Aspidistra bifolia* Aver., Tillich & K.S.Nguyen, sp. nov. CPC 8057
96. *Gastrodia khangii* Aver., sp. nov. CPC 8240

Selected field work scenes of current studies

97. Discussion with Xuan Nha nature reserve authorities schedule and locations of field explorations (Xuan Nha nature reserve headquarter)
98. Discussion with local peoples of optimal itineraries to mountain tops (Tan Xuan commune, A Lay village)
99. Research team in forest during field works Chieng Son commune, Chieng Son village area)
100. Team member – Nguyen Sinh Khang makes photos of studied plants (Chieng Son commune, Pha Luong village area)
101. Team member – Nguyen Sinh Khang makes photos of studied plants (Van Ho commune, Hua Tat village area)
102. Team member – Nguyen Thanh Son collects pine specimens for voucher herbaria (Chieng Son commune, Pha Luong village area)
103. Team leader – Leonid Averyanov collects specimens for voucher herbaria (Van Ho commune, Hua Tat village area)
104-106. Team members and associated local people collect plant specimens for voucher herbaria on main Pha Luong Mountain summit.
107. Team members on western part of main Pha Luong Mountain summit.
108. Team leader – Leonid Averyanov inspects timber of rare conifer – *Cunninghamia konishii* Hayata almost extinct in the area (Tan Xuan commune, A Lay village)
109-115. Processing and photography of voucher herbaria during field works (all team members – Leonid V. Averyanov, Nguyen Tien Hiep, Nguyen Sinh Khang, Nguyen Thanh Son, Chuong Quang Ngan and Tatiana V. Maisak).







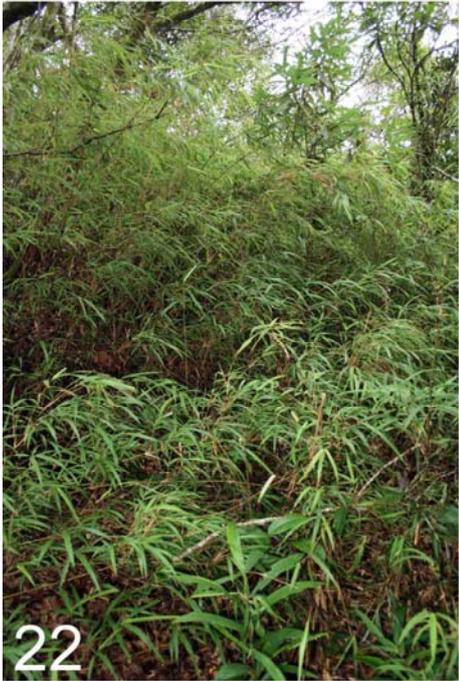
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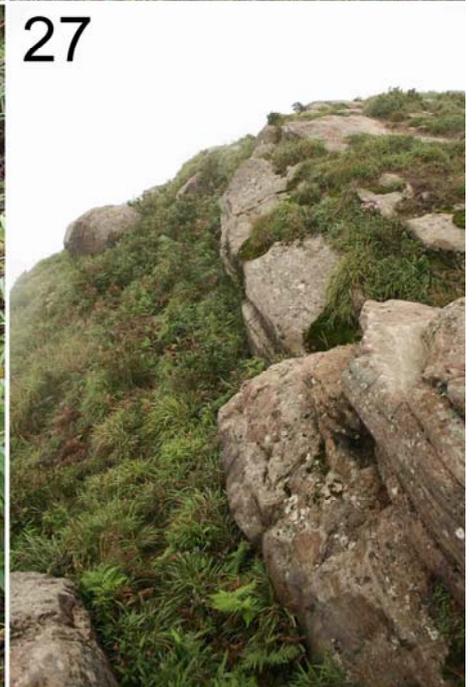
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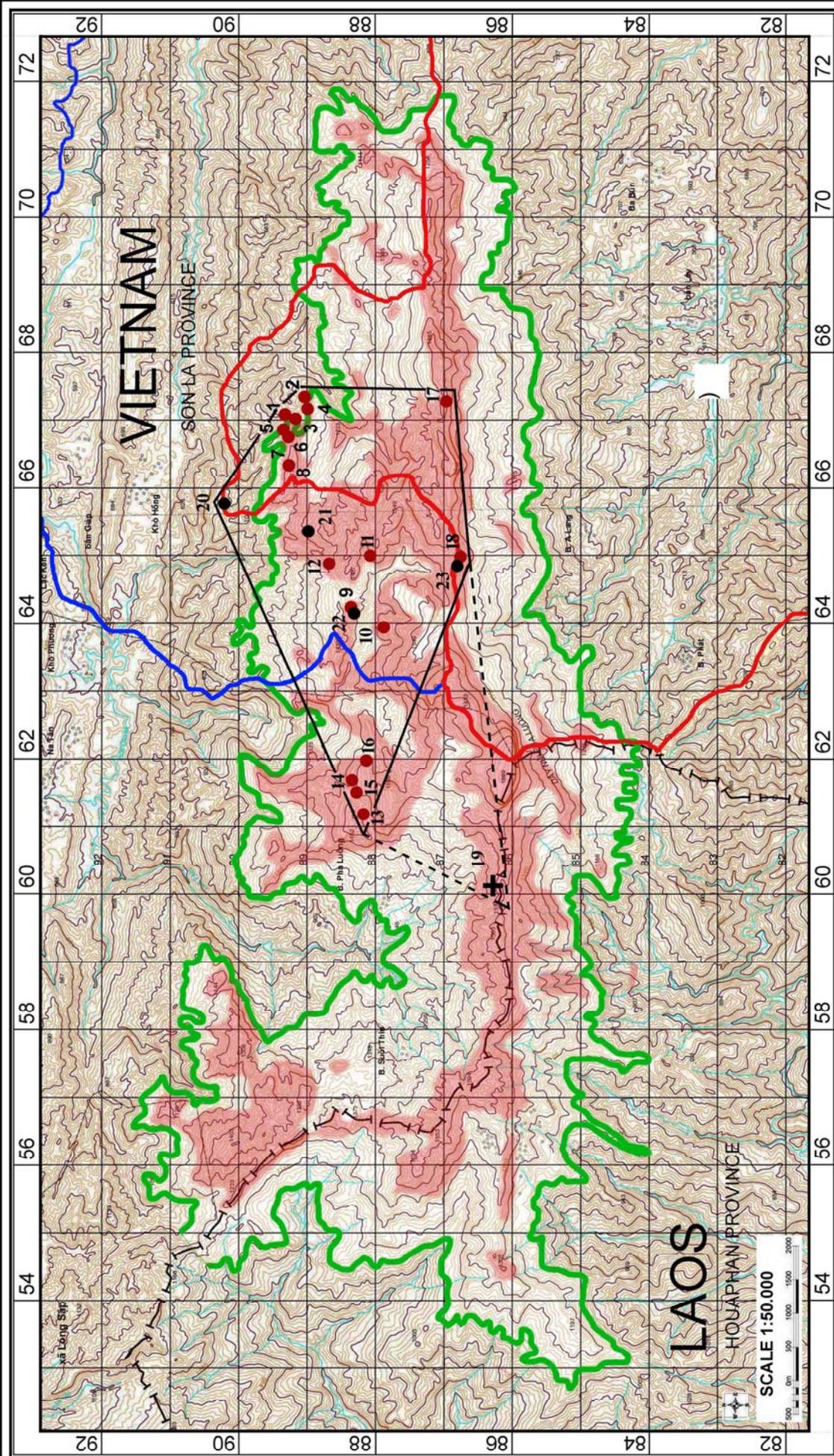
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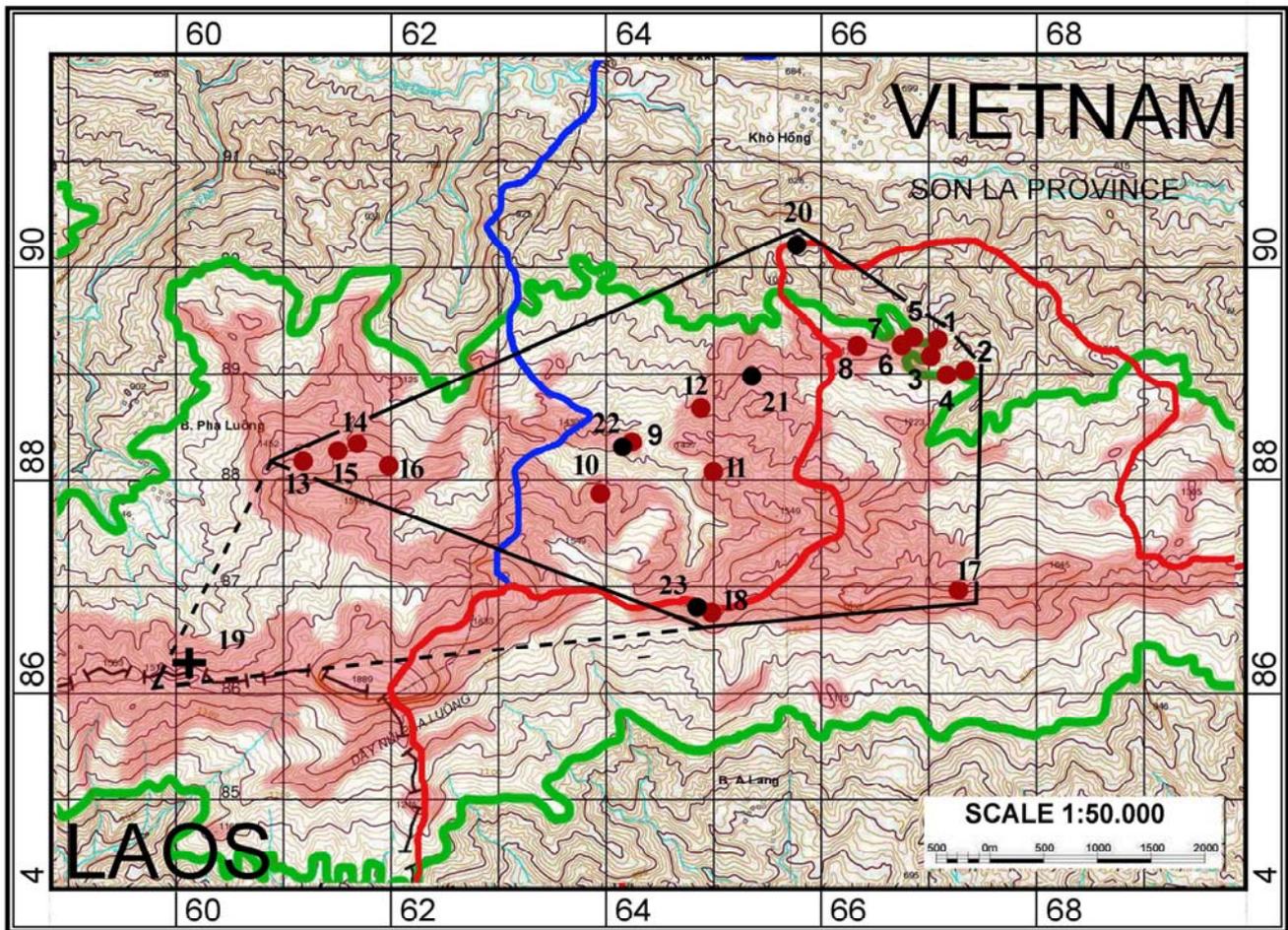


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- Maximal suitable area of possible occurrence (less than 74 km²)
- Maximal suitable area of possible occupancy (less than 25 km²)
- Documented existing subpopulations (1-18, 20-23)
- Location of extinct subpopulation (19)

Distribution of *Pinus cernua*

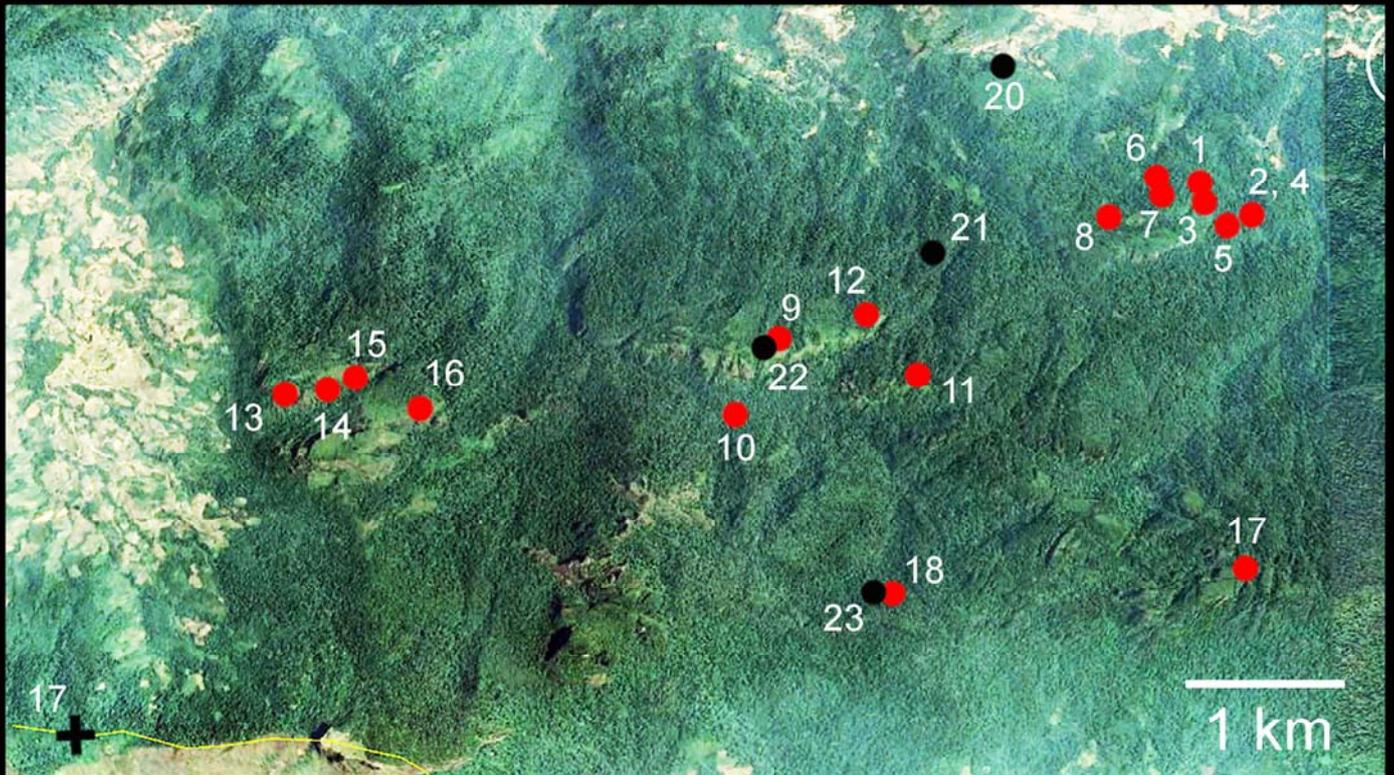


Distribution of *Pinus cernua*

Former and present actual area of occurrence

- Polygon of former occurrence area ($\approx 20 \text{ km}^2$, for about 2010)
- Polygon of present actual occurrence area ($\approx 15 \text{ km}^2$, for 2016)
- Presently existing subpopulations: 1-12 - locations discovered in 2013-2015 (Averyanov et al., 2015); 13-18 - locations discovered by our research group in 2016; 20-23 - locations discovered by other researches in 2015-2016 (Nguyen Minh Tam et al., 2015; Businsky, 2016, pers.com).
- + Location of extinct population (19) detected by our research group in 2016.

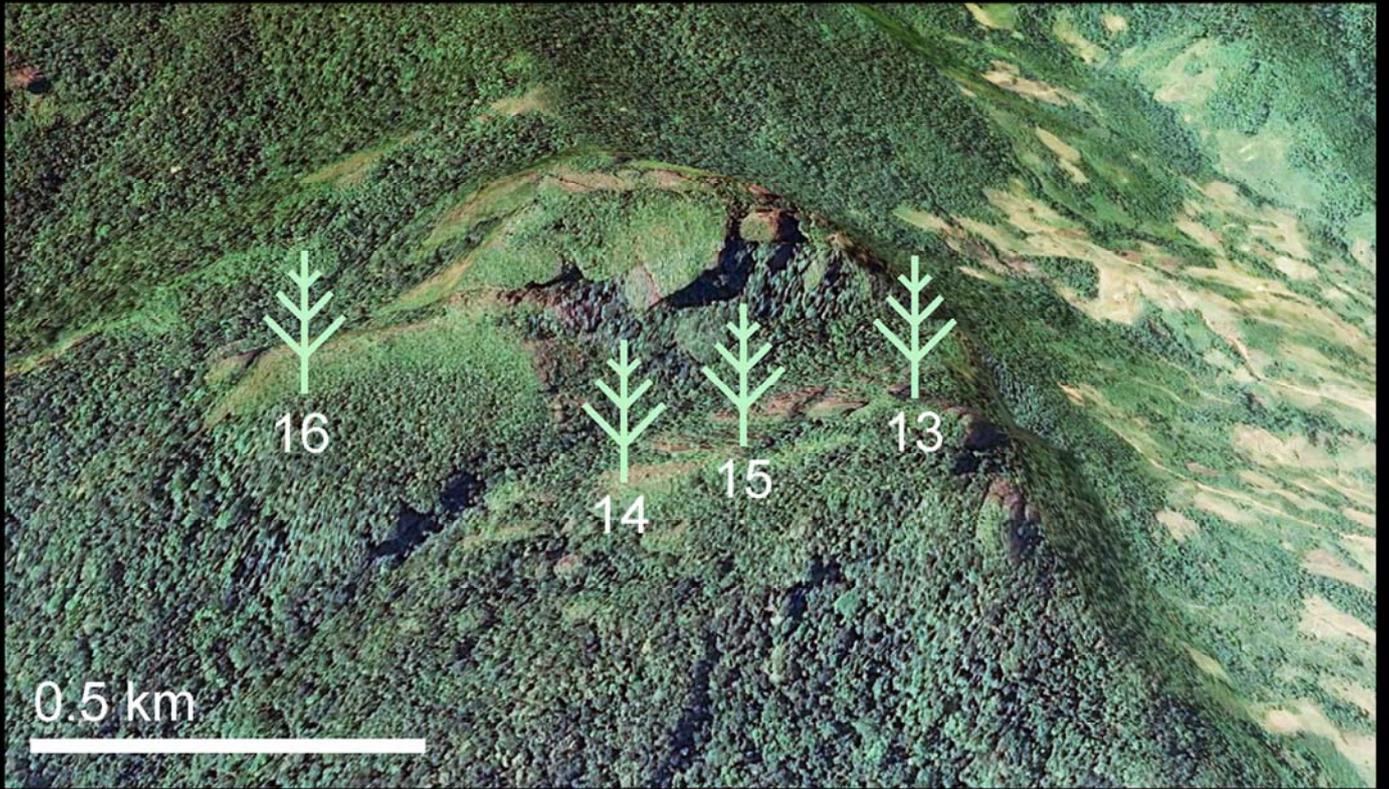
Estimated present actual occupancy area for 2016 less than 5 km^2



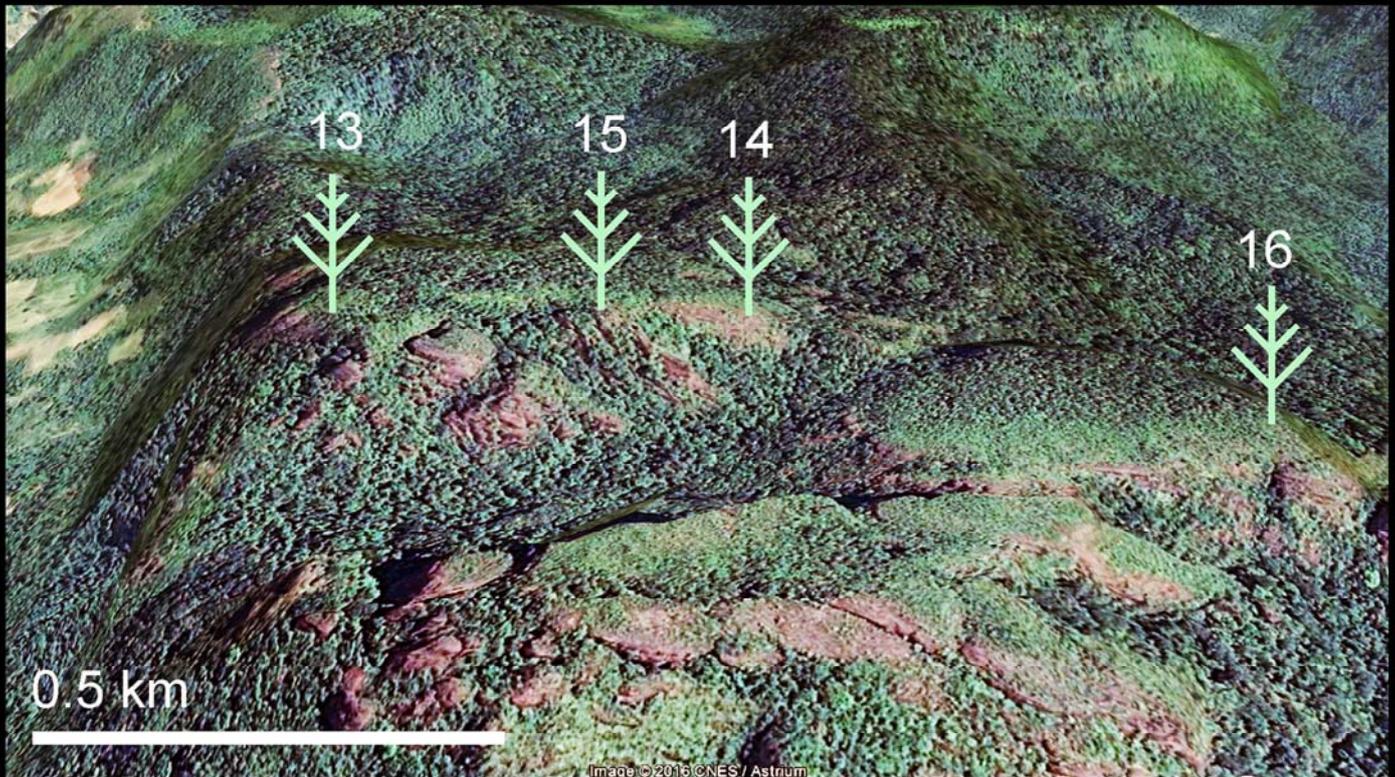
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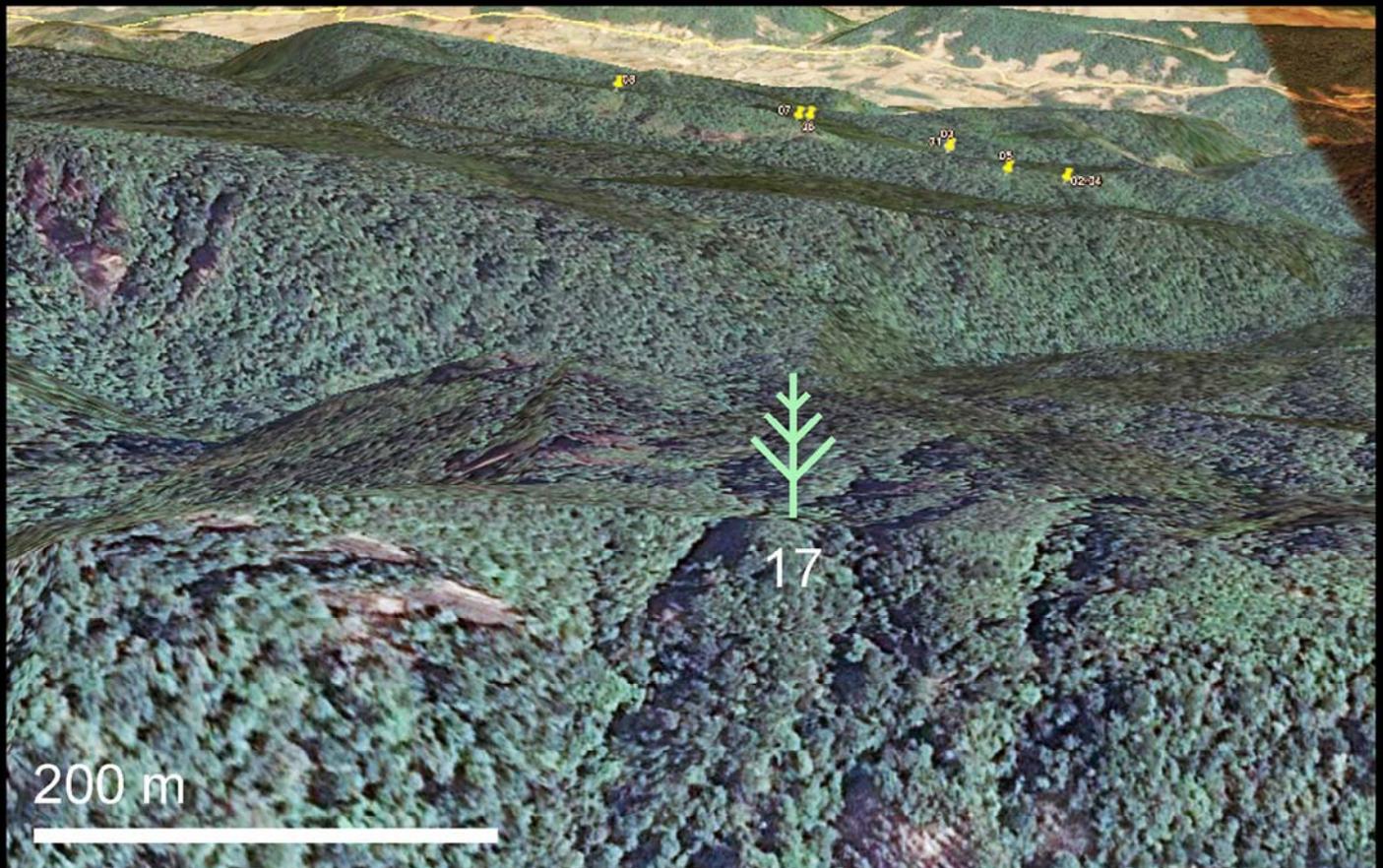
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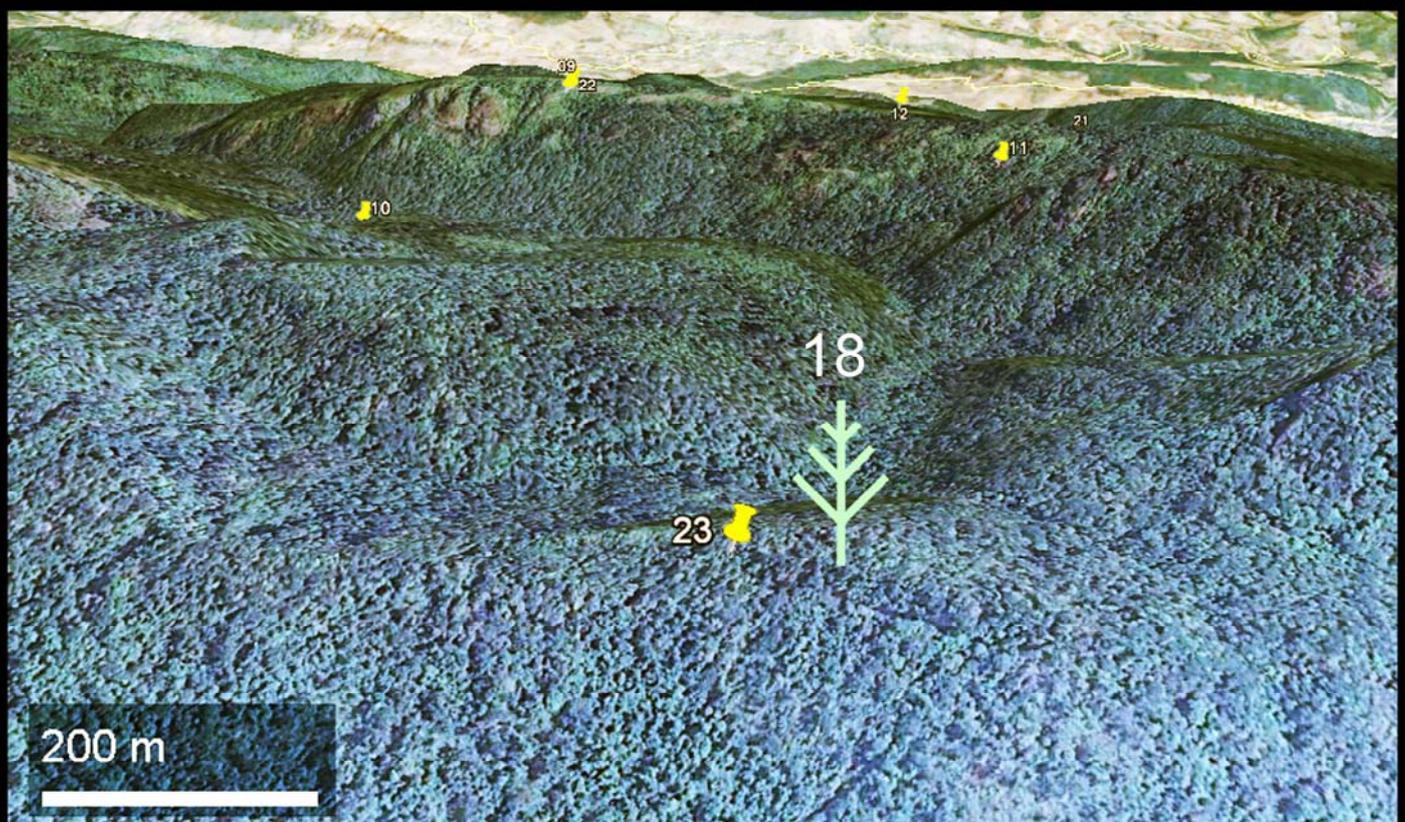
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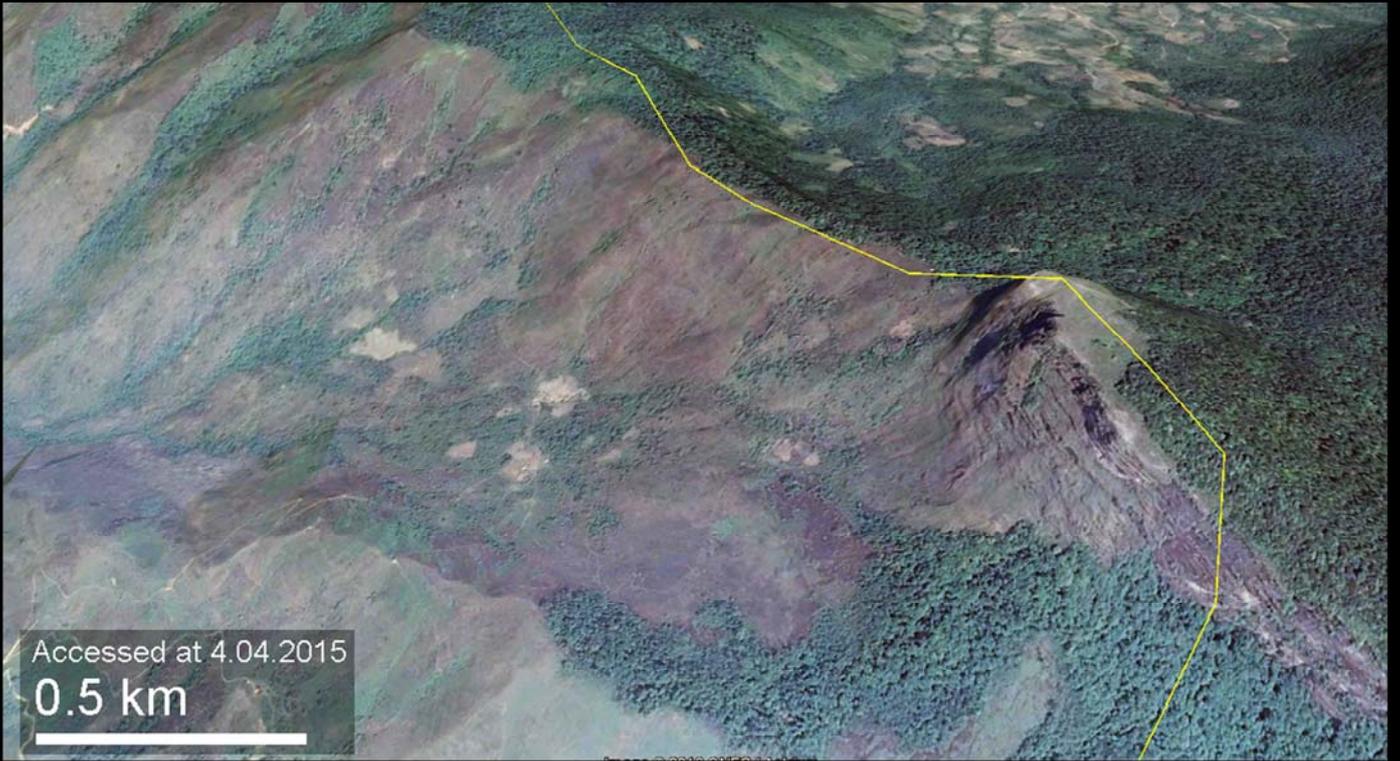
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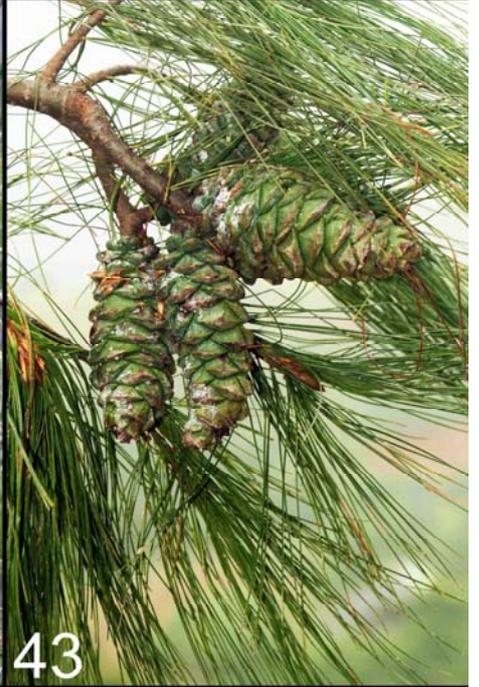
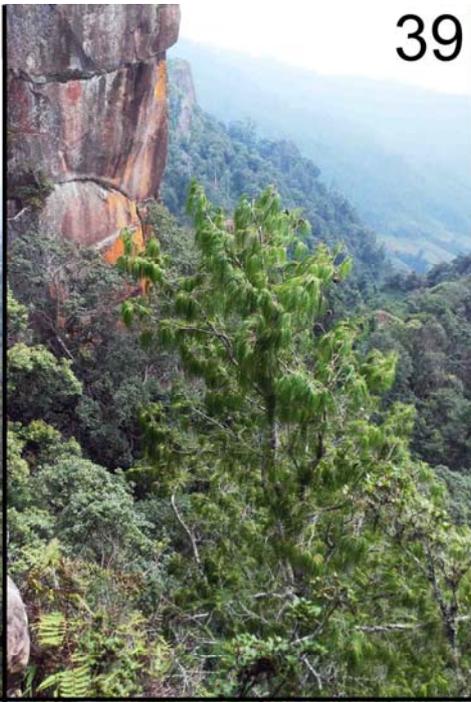
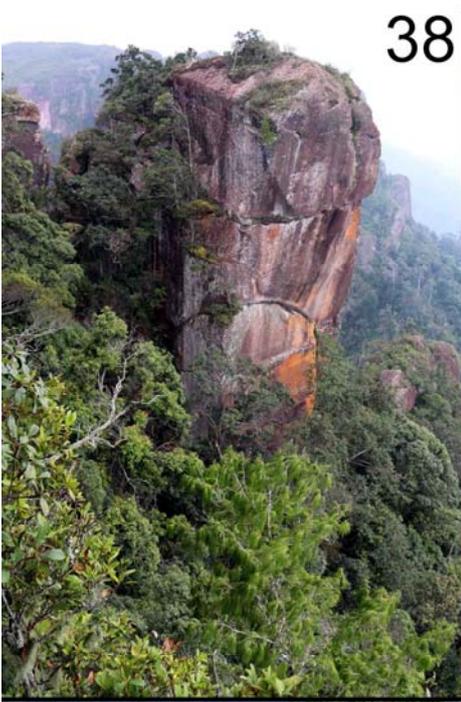
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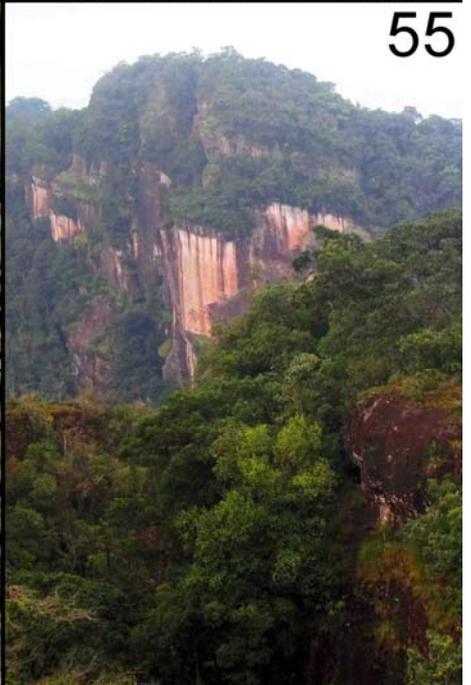
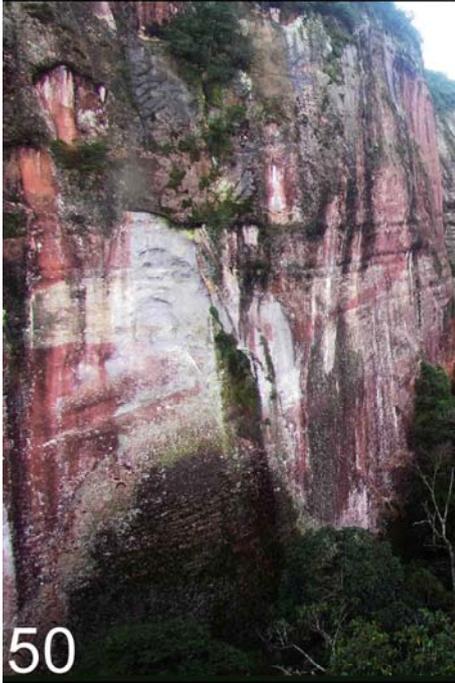
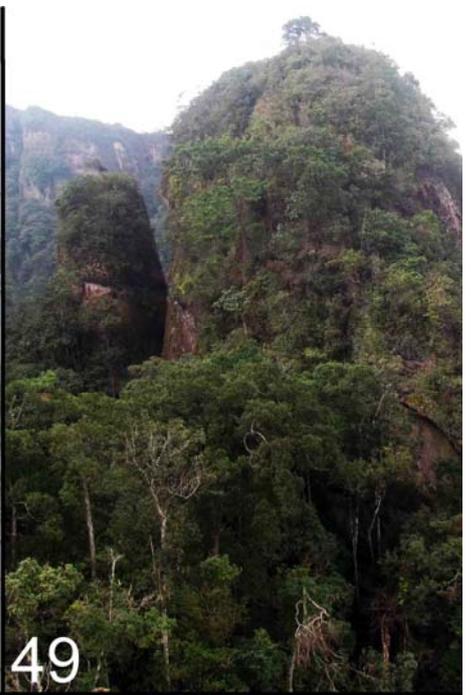


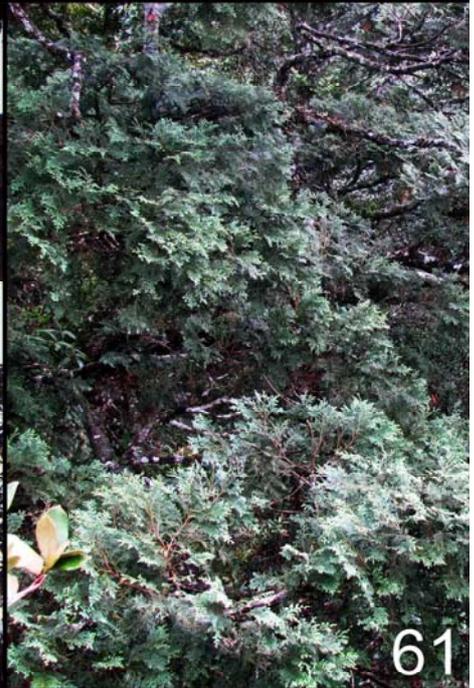
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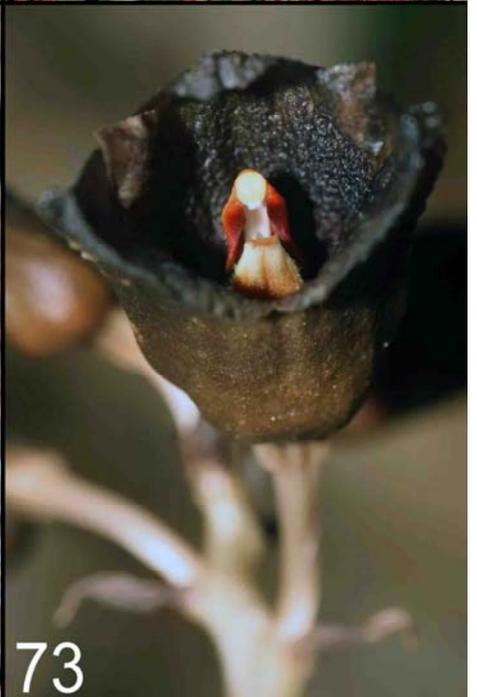


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FLORA OF VIETNAM

Pinus cernua Aver., K.S.Nguyen & T.H.Nguyen

Son La Prov., Moc Chau Distr., Chieng Son comm., Pha Luong village, Pha Luong Mountain system. Primary mixed evergreen forest with bamboo on eroded red-brown sandstone near mountain top at elevation 1350-1400 m around point 20°41'41.1N 104°37'48.9E (20°41'38.9N 104°37'47.6E; 20°41'37.9N 104°37'51.1E). Tree 10-15 m tall. Locally common. About 20 trees were recorded.

23 September 2016 CPC 8013

Coll.: L.Averyanov, N.T.Hiep, N.S.Khang, C.Q.Ngan, T.V.Maisak, N.T.Son. d-EXSICCATES OF VIETNAMESE FLORA 0265/CPC 8013 © L.Averyanov



FLORA OF VIETNAM

Pinus cernua Aver., K.S.Nguyen & T.H.Nguyen

Son La Prov., Moc Chau Distr., Chieng Son comm., Pha Luong village, Pha Luong Mountain system. Primary broad-leaved evergreen forest with *Pinus cernua*, *Fokienia hodginsii* and bamboo on eroded red-brown sandstone near mountain top at elevation 1350 m a.s.l. around point 20° 41' 36.4N 104° 37' 46.8E. Tree 8-10 m tall. Rare, 6 trees seen only. 24 September 2016. CPC 8019
 Coll.: L.Averyanov, N.T.Hiep, N.S.Khang, C.Q.Ngan, T.V.Maisak, N.T.Son.
 6-EXSICCATES OF VIETNAMESE FLORA 0266/CPC 8019 © @ L.Averyanov

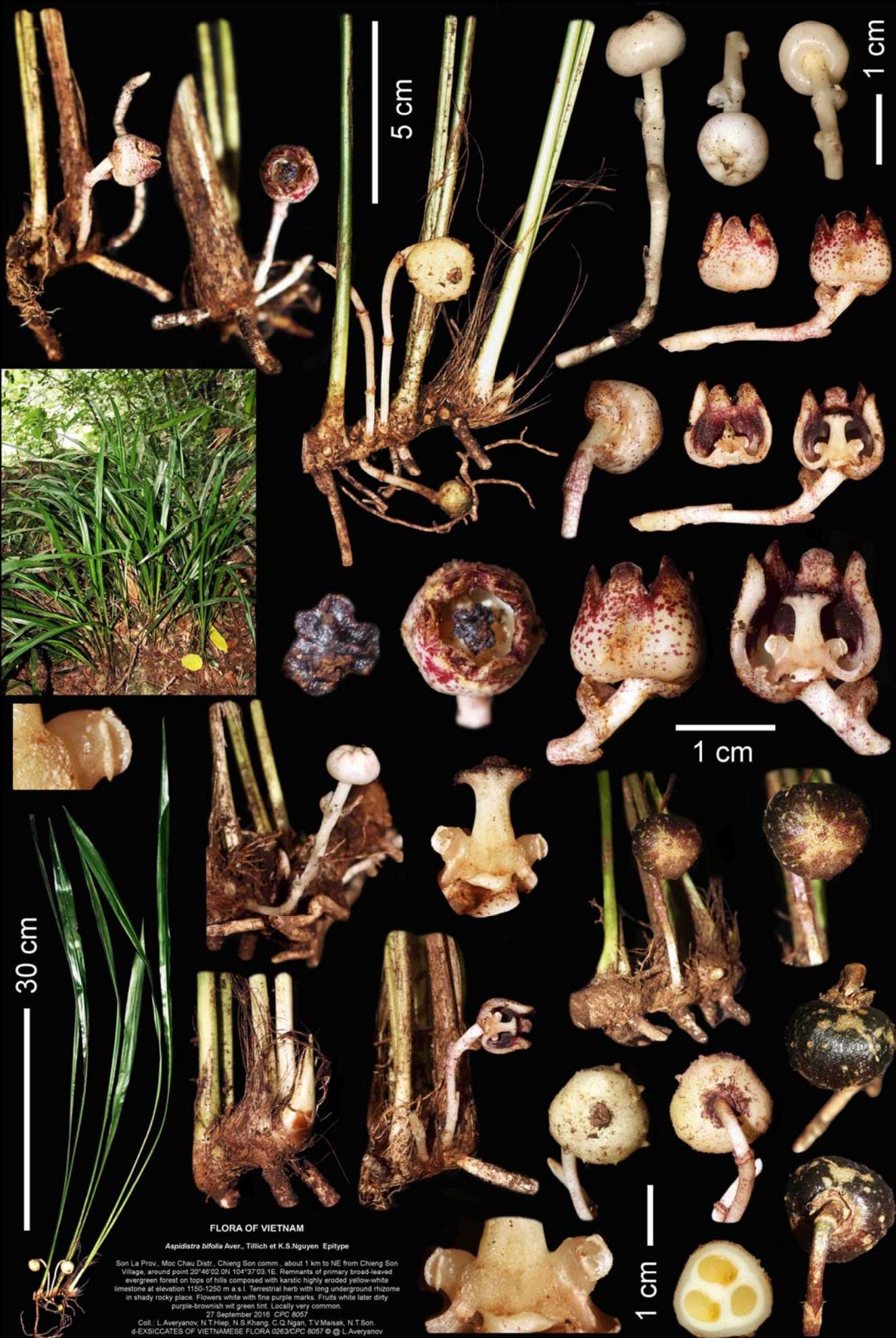


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FLORA OF VIETNAM

Pinus cernua Aver., K.S.Nguyen & T.H.Nguyen

Son La Prov., Van Ho Distr., Tan Xuan comm., Bun village, around point 20°40'58.4N 104°41'02.8E. Primary broad-leaved evergreen forest on highly eroded red-brown sandstone at elevation 1500-1550 m a.s.l. Tree about 15 m tall and 40 cm DBH. Not common. About 20 trees seen. 27 September 2016. CPC 8107. Coll.: L.Averyanov, N.T.Hiep, N.S.Khang, C.O.Ngan, T.V.Maisak, N.T.Son. α-EXSICCATES OF VIETNAMESE FLORA 0267/CPC 8107 © L.Averyanov



FLORA OF VIETNAM

Aspidistra bifolia Aver., Tillich et K.S.Nguyen Epitype

Son La Prov., Moe Chau Distr., Chieng Son comm., about 1 km to NE from Chieng Son Village, around point 20°46'02.0N, 104°37'03.1E. Remnants of primary broad-leaved evergreen forest on tops of hills composed with karstic highly eroded yellow-white limestone at elevation 1150-1250 m a.s.l. Terrestrial herb with long underground rhizome in shady rocky place. Flowers white with fine purple marks. Fruits white later dirty purple-brownish wit green tint. Locally very common.

27 September 2016 CPC 8057

Coll.: L.Averyanov, N.T.Hiep, N.S.Khang, C.Q.Ngan, T.V.Maisak, N.T.Son.
 ©-EXSICCATES OF VIETNAMESE FLORA 0263-CPC 8057 © L.Averyanov

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FLORA OF VIETNAM

Gastrodia khangii Aver. Epitype

Son La Prov., Van Ho Distr., Van Ho comm., Hua Tai village, around point 20°46'21.7N 104°47'47.5E. Dense bamboo forest on alluvial slope of remnant mountain composed with highly eroded karstic light gray marble-like limestone at elevation about 1100 m a.s.l. Terrestrial achlorophyllous mycotrophic tuberiferous herb. Flowers dark brown, lip and column wings red, column itself, anther and lip calli white. Rare. 2 October 2016. CPC 8240. Photos. Coll.: L. Averyanov, N.T.Hiep, N.S.Khang, C.Q.Ngan, T.V.Maisak, N.T.Son. ©EXSICCATES OF VIETNAMESE FLORA 0264/CPC 8240 © L. Averyanov



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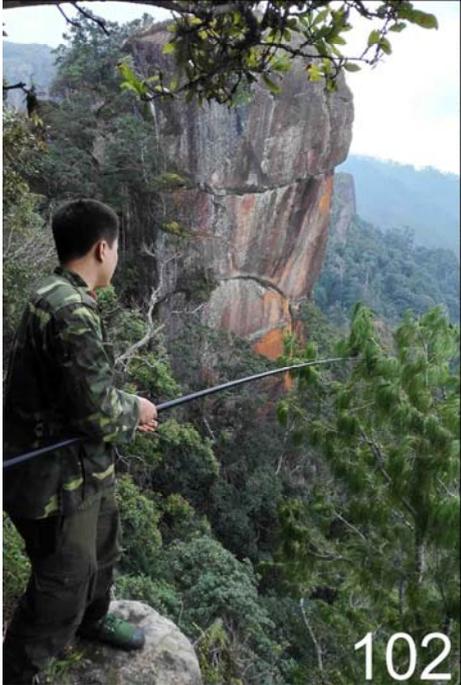
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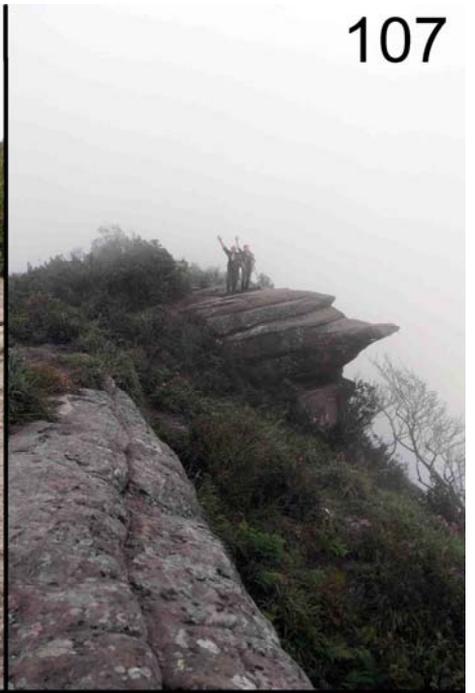
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Appendix 1.

Appendix 1.

Summarized data on structure of plant communities observed in Pha Luong Mountains

1. Evergreen broad-leaved tropical submontane forest

Summarized data based on vegetation descriptions

Date: September - October 2016. Made by Averyanov L. et al.

Position: Northern Vietnam, Son La province, Pha Luong Mountains 20°40'00'' – 20°42'50''N, 104°36'30'' – 104°41'40''E.

Elevation: (500)600-1750(1800) m. Slope exposition W, N, E & S. Slope inclination 0-40(50)°.

Parental soil material: solid red-brown sandstone.

Leaf litter: 0-5 cm thick with projected coverage 0-100%.

Soil: thin, with brown humus-containing horizon (20)30-40(50) cm.

Zonal (elevational) plant community: Evergreen broad-leaved tropical submontane forest.

Plant community structure:

1 stratum (tree storey):

Height in m.	Diameter (in cm at BH)	Projective coverage in %.
15-30(35)	(30)40-110(120)	30-60(70)

Dominants: *Castanopsis* ssp., *Cinnamomum* ssp., *Diplopanax vietnamensis*, *Lithocarpus* ssp., *Parakmeria robusta*, *Quercus* ssp., *Sloanea* sp.

Associates: *Eberhardtia* sp., *Gordonia* sp., *Liquidambar formosana*, *Litsea* ssp., *Schima wallichii*, *Styrax* sp.

2 stratum (tree storey):

Height in m.	Diameter (in cm at BH)	Projective coverage in %.
5-15	(7)10-30(40)	30-70(80)

Dominants: no certain dominants

Associates: *Acer* sp., *Aglaiia* ssp., *Antidesma* sp., *Camellia* sp., *Citrus* sp., *Diospyros* sp., *Ficus gibbosa*, *Livistona chinensis*, *Magnolia foveolata*, *Magnolia megaphylla*, *Magnolia* ssp., *Manglietia dandyi*, *Michelia balansae*, *Michelia* ssp., *Ormosia* sp., *Symplocos* sp.,

Wikstroemia sp.

3 stratum (shrubs):

Height in m.	Projective coverage in %.
2-5	10-40(50)

Dominants: *Blastus* ssp., *Ixora* sp., *Lasianthus* sp., *Licuala* sp., *Psychotria* ssp.

Associates: *Ardisia* ssp., *Chloranthus* sp., *Clausena* sp., *Croton* sp., *Dichroa febrifuga*, *Medinilla* sp., *Oxyspora* ssp., *Pinanga* sp., *Polygala* sp., *Rhaphis* sp., *Sarcandra glabra*, *Schefflera* sp., *Silvianthus tonkinensis*, *Staphyllea* sp.

4 stratum (herbs):

Height in m.	Projective coverage in %.
0.03-2	(0)5-20(35)

Dominants: *Alpinia* sp., *Aspidistra nutans*, *Aspidistra* sp., *Aspidistra subtrotata*, *Begonia delavayi*, *Begonia handelii*, *Begonia hemsleyana*, *Begonia howii*, *Begonia* sp., *Begonia tetragona*, *Colysis* sp., *Diplasium* sp., *Diplazium donianum*, *Elatostema* ssp., *Leptochylus* sp., *Microlepia* sp., *Mycetia* ssp., *Ophiopogon* ssp., *Ophiorrhiza* ssp., *Peliosanthes griffithii*, *Peliosanthes* ssp., *Pellionia* ssp., *Phyllagathis pulchella* sp. nov., *Polystichum* sp., *Pteris* sp., *Selaginella* sp., *Sonerila* ssp., *Spatholirion puluogense*.

Associates: *Anoectochilus annamensis*, *Anoectochilus roxburghii*, *Apostasia wallichii*, *Aspidistra bifolia*, *Calanthe alleizettii*, *Calanthe clavata*, *Calanthe densiflora*, *Calanthe puberula*, *Calanthe* sp., *Calanthe sylvatica*, *Clerodendron* ssp., *Cymbidium ensifolium*, *Cymbidium kanran*, *Cymbidium lancifolium*, *Disporum* sp., *Geodorum* sp., *Gomphostemma* sp., *Goodyera foliosa*, *Habenaria medioflexa*, *Habenaria* sp., *Impatiens* sp., *Kaempferia rotunda*, *Lindsaea orbiculata*, *Liparis nervosa*, *Nervilia aragoana*, *Ophiopogon alatus*, *Ophiopogon intermedius*, *Ophiopogon tonkinensis*, *Peliosanthes kenhilloides*, *Phyllagathis* sp., *Rhomboda petelotii*, *Streptolirion volubile*, *Tainia latifolia*, *Zeuxine nervosa*, *Zingiber cochleariforme*, *Zingiber guangxiense*, *Zingiber recurvatum*.

5 stratum (mosses & lichens):

Height in cm.	Projective coverage in %.
(0.1)0.5-3	0-80(100)

Dominants: Bryophytes undeterm.

Associates: *Crepidomanes auriculatum*, *Mecodium* sp., *Trichomenes* sp. (all Hymenophyllaceae).

Non strata vegetation:

Epiphytes, creeping lianas & semi-epiphytes:

Dominants: *Bulbophyllum ambrosia*, *Bulbophyllum psychoon*, *Bulbophyllum* ssp., *Callostylis rigida*, *Ceratostylis himalaica*, *Coelogyne fimbriata*, *Davallia* sp., *Dendrobium chrysanthum*, *Dendrobium nobile*, *Dendrobium spatella*, *Dendrobium thyrsoflorum*, *Dischidia* sp., *Drynaria* sp., *Epigeneium amplum*, *Epigeneium chapaense*, *Eria panna*, *Eria siamensis*, *Eria* ssp., *Eria thao*, *Hoya* sp., *Lemmaphyllum microphyllum*, *Lepisorus* sp., *Liparis viridiflora*, *Microsorium* sp., *Panisea* ssp., *Peperomia* sp., *Pholidota articulata*, *Pholidota chinensis*, *Pyrrosia* sp., *Thelasis pygmaea*, *Thrixspermum centipeda*.

Associates: *Aeschynanthus mendumiae*, *Aeschynanthus* ssp., *Bulbophyllum apodum*, *Bulbophyllum biesetoides*, *Bulbophyllum pecten-*

veneris, *Bulbophyllum reptans*, *Cleisostoma striatum*, *Cleisostoma williamsonii*, *Coelogyne* ssp., *Cymbidium lowianum*, *Cymbidium* ssp.,

Dendrobium brymerianum, *Dendrobium eriiflorum*, *Dendrobium falconeri*, *Dendrobium fimbriatum*, *Dendrobium hancockii*, *Dendrobium jenkinsii*, *Eria apertiflora*, *Eria calcarea*, *Eria rhomboidalis*, *Huperzia* sp., *Hygrochilus parishii*, *Liparis longispica*, *Liparis pumila*, *Luisia* ssp., *Luisia zollingeri*, *Lycopodium* sp., *Lysionotus chingii*, *Oberonia falconeri*, *Oberonia* ssp., *Ornithochilus difformis*, *Pholidota recurva*, *Scindapsus* sp., *Smitinandia helferi*, *Stereochilus brevirachis*, *Sunipia scariosa*, *Thrixspermum stelioides*, *Trichotosia microphylla*, *Trichotosia pulvinata*, *Vanda* sp.

Lithophytes:

Dominants: *Antrophium* sp., *Argostemma* ssp., *Asplenium antrophioides*, *Asplenium rupestre*, *Asplenium* sp., *Carex* sp., *Chirita* ssp., *Didymocarpus* sp., *Eria globulifera*, *Eria siamensis*, *Hedyotis* ssp., *Liparis bootanensis*, *Liparis viridiflora*, *Peperomia* sp., *Rhynchotechum* sp., *Sonerila* ssp., *Vittaria hainanensis*, *Vittaria* sp.

Associates: *Aglamorpha acuminata*, *Appendicula hexandra*, *Boea* ssp., *Calcareaoboea coccinea*, *Collabium chapaensis*, *Collabium chinense*, *Eria bambusifolia*, *Eria calcarea*, *Eria carinata*, *Eria corneri*, *Eria rhomboidalis*, *Flickingeria fimbriata*, *Hedychium* sp., *Hedychium yunnanense*, *Lilium poilanei*, *Liparis averyanoviana*, *Liparis balansae*, *Liparis dendrochiloides*, *Liparis superposita*, *Oreocharis argyrophylla*, *Oreocharis blepharophylla*, *Oreocharis* sp., *Paraboea* sp., *Streptocarpus* sp., *Vittaria elongata*.

Climbers, lianas and climbing shrubs:

Dominants: no certain dominants

Associates: *Actinidia* sp., *Alphonsea* sp., *Artobotrys* sp., *Illigera* sp., *Popovia* sp.

Riparian and subaquatic plants of specific life forms:

Angiopteris evecta, *Bolbithis* sp. *Tupistra khangii*, *Tupistra* sp.

Plants of specific life forms:

Achlorophyllous root parasites: *Balanophora laxiflora*, *Balanophora* sp.

Achlorophyllous mycotrophic plants: *Didymoplexis pallens*, *Gastrodia khangii*, *Lecanorchis vietnamica*.

2. Evergreen mixed tropical submontane forest

Summarized data based on vegetation descriptions

Date: September - October 2016. Made by Averyanov L. et al.

Position: Northern Vietnam, Son La province, Pha Luong Mountains 20°40'00'' – 20°42'50''N, 104°36'30'' – 104°41'40''E.

Elevation: (800)900-1500(1550) m. Slope exposition W, N, E & S. Slope inclination 0-70(80)°.

Parental soil material: solid red-brown sandstone.

Leaf litter: 0-3 cm thick with projected coverage 0-100%.

Soil: thin, with brown humus-containing horizon (5)10-20(30) cm.

Zonal (elevational) plant community: Evergreen mixed tropical submontane forest.

Plant community structure:

1 stratum (tree storey):

Height in m.	Diameter (in cm at BH)	Projective coverage in %.
15-30(35)	(30)35-45(60)	30-60(70)

Dominants: *Castanopsis* ssp., *Cinnamomum* ssp., *Diplopanax vietnamensis*, *Lithocarpus* ssp., *Litsea* ssp., *Quercus* ssp., *Schima wallichii*.

Associates: *Acer* sp., *Amentotaxus argotaenia*, *Amentotaxus yunnanensis*, *Cephalotaxus mannii*, *Dacrycarpus imbricatus*, *Fokienia hodginsii*, *Gordonia* sp., *Keteleeria evelyniana*, *Pinus cernua*, *Pinus latteri*, *Podocarpus neriifolius*.

2 stratum (tree storey):

Height in m.	Diameter (in cm at BH)	Projective coverage in %.
5-15	(7)10-20(25)	(15)20-45(55)

Dominants: no certain dominants

Associates: *Acer* sp., *Aglaiia* ssp., *Eriobotrya* sp., *Livistona chinensis*, *Photinia cucphuongensis*, *Schefflera* sp., *Symplocos* sp., *Wikstroemia* sp.

3 stratum (shrubs):

Height in m.	Projective coverage in %.
2-5	10-30(40)

Dominants: *Ixora* sp., *Lasianthus* sp., *Psychotria* ssp.

Associates: *Ardisia* ssp., *Camellia* sp., *Lasianthus* sp., *Licuala* sp., *Oxyspora* sp., *Psychotria* ssp., *Schefflera* sp.

4 stratum (herbs):

Height in m.	Projective coverage in %.
0.03-2	(0)5-20(30)

Dominants: *Diplasium* sp., *Elatostema* ssp., *Microlepis* sp., *Pellionia* ssp., *Polystichum* sp., *Selaginella* sp.

Associates: *Alpinia* sp., *Goodyera schlechtendalana*, *Ophiorrhiza* ssp., *Sonerila* ssp., *Tainia latifolia*, *Zingiber cochleariforme*, *Zingiber guangxiense*, *Zingiber recurvatum*.

5 stratum (mosses & lichens):

Height in cm.	Projective coverage in %.
(0.1)0.5-3	10-80(100)

Dominants: Bryophytes and lichens undeterm.

Associates: *Trichomenes* sp. (Hymenophyllaceae), Bryophytes and lichens undeterm.

Non strata vegetation:

Epiphytes & semi-epiphytes:

Dominants: *Bulbophyllum ambrosia*, *Bulbophyllum reptans*, *Callostylis rigida*, *Ceratostylis himalaica*, *Coelogyne fimbriata*, *Davallia* sp., *Dendrobium spatella*, *Dendrobium thyrsoiflorum*, *Dischidia* sp., *Drynaria* sp., *Epigeneium amplum*, *Epigeneium chapaense*, *Eria pannea*, *Eria siamensis*, *Eria* ssp., *Eria thao*, *Lemmaphyllum microphyllum*, *Lepisorum* sp., *Microsorium* sp., *Pholidota articulata*, *Pholidota chinensis*, *Pholidota recurva*, *Pyrrosia* sp., *Thelasis pygmaea*.

Associates: *Aeschynanthus mendumiae*, *Aeschynanthus* ssp., *Bulbophyllum apodum*, *Bulbophyllum biesetoides*, *Bulbophyllum pecten-veneris*, *Bulbophyllum psychoon*, *Bulbophyllum* ssp., *Cleisostoma striatum*, *Cleisostoma williamsonii*, *Coelogyne* ssp., *Cymbidium* ssp., *Dendrobium brymerianum*, *Dendrobium chrysanthum*, *Dendrobium falconeri*, *Dendrobium fimbriatum*, *Dendrobium hancockii*, *Dendrobium nobile*, *Eria apertiflora*, *Eria bambusifolia*, *Hoya* sp., *Huperzia* sp., *Hygrochilus parishii*, *Liparis longispica*, *Liparis pumila*, *Liparis viridiflora*, *Luisia* ssp., *Luisia zollingeri*, *Lycopodium* sp., *Oberonia falconeri*, *Oberonia* ssp., *Ornithochilus difformis*, *Panisea* ssp., *Peperomia* sp., *Smitinandia helferi*, *Stereochilus brevirachis*, *Sunipia scariosa*, *Thrixspermum stelidioides*, *Trichotosia microphylla*, *Trichotosia pulvinata*, *Vanda* sp.

Lithophytes:

Dominants: *Asplenium antrophioides*, *Asplenium rupestre*, *Carex* sp., *Eria carinata*, *Eria globulifera*, *Eria siamensis*, *Flickingeria fimbriata*, *Liparis averyanoviana*, *Liparis bootanensis*, *Liparis viridiflora*, *Pyrrosia* ssp., *Vittaria hainanensis*, *Vittaria* sp.

Associates: *Antrophium* sp., *Appendicula hexandra*, *Argostemma* ssp., *Asplenium* sp., *Boea* ssp., *Chirita* ssp., *Collabium chapaensis*, *Collabium chinense*, *Cymbidium lowianum*, *Didymocarpus* sp., *Eria bambusifolia*, *Eria calcarea*, *Eria corneri*, *Hedychium* sp., *Hedychium yunnanense*, *Hedyotis* ssp., *Lilium poilanei*, *Liparis balansae*, *Liparis dendrochiloides*, *Liparis superposita*, *Oreocharis argyrophylla*, *Oreocharis blepharophylla*, *Oreocharis* sp., *Paraboea* sp., *Peperomia* sp., *Rhynchotechum* sp., *Sonerila* ssp., *Streptocarpus* sp., *Vittaria elongata*.

Climbers & lianas:

Dominants: no certain dominants

Associates: *Actinidia* sp., *Dioscorea* sp., *Smilax* sp., *Tetrastigma* sp.

Riparian and subaquatic plants of specific life forms:

no

Plants of specific life forms:

no

3. Evergreen coniferous tropical submontane forest

Summarized data based on vegetation descriptions

Date: September - October 2016. Made by Averyanov L. et al.

Position: Northern Vietnam, Son La province, Pha Luong Mountains 20°40'00'' – 20°42'50''N, 104°36'30'' – 104°41'40''E.

Elevation: (800)900-1500(1550) m. Slope exposition W, N, E & S. Slope inclination 0-70(90)°.

Parental soil material: solid red-brown sandstone.

Leaf litter: 0-3 cm thick with projected coverage 0-100%.

Soil: thin, with brown humus-containing horizon (5)10-20(30) cm.

Zonal (elevational) plant community: Evergreen coniferous tropical submontane forest.

Plant community structure:

1 stratum (tree storey):

Height in m.	Diameter (in cm at BH)	Projective coverage in %.
12-20(25)	(30)35-60(80)	15-35(45)

Dominants: *Fokienia hodginsii*, *Pinus cernua*.

Associates: *Acer* sp., *Amentotaxus argotaenia*, *Amentotaxus yunnanensis*, *Camellia* sp., *Castanopsis* ssp., *Cephalotaxus mannii*, *Cinnamomum* ssp., *Dacrycarpus imbricatus*, *Gordonia* sp., *Lithocarpus* ssp., *Litsea* ssp., *Pinus latteri*, *Podocarpus neriifolius*, *Quercus* ssp., *Schefflera* sp., *Schima wallichii*, *Symplocos* sp.

2 stratum (tree storey):

Height in m.	Diameter (in cm at BH)	Projective coverage in %.
5-12	(7)10-20(25)	(15)23-50(60)

Dominants: no certain dominants

Associates: *Acer* sp., *Aglaiia* ssp., *Eriobotrya* sp., *Lithocarpus* ssp., *Photinia cucphuongensis*, *Quercus* ssp., *Schefflera* sp., *Symplocos* sp.

3 stratum (shrubs):

Height in m.	Projective coverage in %.
2-5	(10)15-40(45)

Dominants: no certain dominants.

Associates: *Ardisia* ssp., *Camellia* sp., *Eriobotrya* sp., *Gaultheria fragrantissima*, *Gaultheria* sp., *Ilex* sp., *Leucothoe* sp., *Lyonia ovalifolia*, *Lyonia* ssp., *Oxyspora* sp., *Photinia cucphuongensis*, *Psychotria* ssp., *Rhododendron* ssp., *Schefflera* sp.

4 stratum (herbs):

Height in m.	Projective coverage in %.
0.03-2	(0)5-15(25)

Dominants: *Diplasium* sp., *Elatostema* ssp., *Pellionia* ssp., *Polystichum* sp., *Selaginella* sp.

Associates: *Alpinia* sp., *Goodyera schlechtendaliana*, *Ophiorrhiza* ssp., *Sonerila* ssp., *Tainia latifolia*, *Zingiber cochleariforme*, *Zingiber guangxiense*, *Zingiber recurvatum*.

5 stratum (mosses & lichens):

Height in cm.	Projective coverage in %.
(0.1)0.5-3	(10)30-80(100)

Dominants: Bryophytes and lichens undeterm.

Associates: *Trichomenes* sp. (Hymenophyllaceae), Bryophytes and lichens undeterm, *Cladonia* ssp.

Non strata vegetation:

Epiphytes & semi-epiphytes:

Dominants: *Bulbophyllum ambrosia*, *Bulbophyllum reptans*, *Callostylis rigida*, *Ceratostylis himalaica*, *Coelogyne fimbriata*, *Davallia* sp., *Dendrobium spatella*, *Dischidia* sp., *Drynaria* sp., *Epigeneium amplum*, *Epigeneium chapaense*, *Eria pannea*, *Eria siamensis*, *Eria* ssp., *Eria*

thao, Lemnaphyllum microphyllum, Lepisorus sp., Microsorium sp., Pholidota articulata, Pholidota chinensis, Pholidota recurva, Pyrrosia sp., Thelasis pygmaea.

Associates: Aeschynanthus mendumiae, Aeschynanthus ssp., Bulbophyllum apodum, Bulbophyllum biesetoides, Bulbophyllum pecten-veneris, Bulbophyllum psychoon, Bulbophyllum ssp., Cleisostoma striatum, Cleisostoma williamsonii, Coelogyne ssp., Cymbidium ssp., Dendrobium brymerianum, Dendrobium chrysanthum, Dendrobium falconeri, Dendrobium fimbriatum, Dendrobium hancockii, Dendrobium nobile, Eria apertiflora, Hoya sp., Huperzia sp., Hygrochilus parishii, Liparis pumila, Liparis viridiflora, Luisia ssp., Luisia zollingeri, Lycopodium sp., Oberonia falconeri, Oberonia ssp., Ornithochilus difformis, Panisea ssp., Peperomia sp., Stereochilus brevirachis, Sunipia scariosa, Thrixspermum stelidioides, Trichotosia microphylla, Trichotosia pulvinata, Vanda sp.

Lithophytes:

Dominants: Asplenium rupestre, Carex sp., Eria carinata, Eria globulifera, Eria siamensis, Flickingeria fimbriata, Liparis averyanoviana, Liparis viridiflora, Pyrrosia ssp., Vittaria hainanensis, Vittaria sp.

Associates: Antrophium sp., Appendicula hexandra, Argostemma ssp., Asplenium sp., Boea ssp., Chirita ssp., Cymbidium lowianum, Didymocarpus sp., Eria bambusifolia, Eria calcarea, Eria corneri, Hedychium sp., Hedychium yunnanense, Hedyotis ssp., Lilium poilanei, Liparis superposita, Oreocharis argyrophylla, Oreocharis blepharophylla, Oreocharis sp., Paraboea sp., Peperomia sp., Rhynchotechum sp., Sonerila ssp., Streptocarpus sp., Vittaria elongata.

Climbers & lianas:

Dominants: no certain dominants

Associates: Actinidia sp., Dioscorea sp., Smilax sp., Tetrastigma sp.

Riparian and subaquatic plants of specific life forms:

no

Plants of specific life forms:

no

4. Evergreen broad-leaved tropical montane cloud forest

Summarized data based on vegetation descriptions

Date: September - October 2016. Made by Averyanov L. et al.

Position: Northern Vietnam, Son La province, Pha Luong Mountains 20°40'00'' – 20°42'50''N, 104°36'30'' – 104°41'40''E.

Elevation: (1500)1700-1860 m. Slope exposition W, N, E & S. Slope inclination 0-70(90)°.

Parental soil material: solid red-brown sandstone.

Leaf litter: 0-3 cm thick with projected coverage 0-100%.

Soil: thin, with brown humus-containing horizon (0)5-10(15) cm.

Zonal (elevational) plant community: Evergreen broad-leaved tropical cloud montane forest.

Plant community structure:

1 stratum (tree & shrub storey):

Height in m.	Diameter (in cm at BH)	Projective coverage in %.
2-5(8)	(3)5-15(30)	(25)50-90(100)

Dominants: Camellia sp., Castanopsis ssp., Gordonia sp., Ilex sp., Lithocarpus ssp., Quercus ssp., Rhododendron ssp., Schima wallichii, Viburnum sp.

Associates: Cinnamomum ssp., Eriobotrya sp., Fokienia hodginsii, Gaultheria fragrantissima Wall., Gaultheria sp., Leucothoe sp., Lithocarpus ssp., Litsea ssp., Lyonia ovalifolia, Lyonia ssp., Photinia cucphuongensis, Podocarpus neriifolius, Psychotria ssp., Rhododendron ssp., Schefflera sp.

2 stratum (herbs):

Height in m.	Projective coverage in %.
0.03-2	(0)5-15(20)

Dominants: Carex sp., Diplasium sp., Elatostema ssp., Pellionia ssp., Plagiogyria pycnophylla, Polystichum sp., Scleria sp., Selaginella sp.

Associates: Alpinia sp., Calanthe alleizettii, Calanthe puberula, Collabium chinense, Cymbidium ensifolium, Cymbidium kanran, Cymbidium lancifolium, Goodyera schlechtendalana, Ophiorrhiza ssp., Sonerila ssp., Tainia latifolia, Zeuxine nervosa, Zingiber cochleariforme, Zingiber quangxiense, Zingiber recurvatum.

3 stratum (mosses & lichens):

Height in cm.	Projective coverage in %.
(0.1)0.5-3	(10)30-80(100)

Dominants: Bryophytes and lichens undeterm.

Associates: Trichomenes sp. (Hymenophyllaceae), Bryophytes and lichens undeterm, Cladonia ssp., Polytrichum ssp.

Non strata vegetation:

Epiphytes & semi-epiphytes:

Dominants: Bulbophyllum ambrosia, Bulbophyllum reptans, Callostylis rigida, Ceratostylis himalaica, Coelogyne fimbriata, Davallia sp., Epigeneium amplum, Epigeneium chapaense, Eria pannea, Eria siamensis, Eria ssp., Eria thao, Lepisorus sp., Microsorium sp., Pholidota articulata, Pholidota chinensis, Pholidota recurva, Pyrrosia sp., Thelasis pygmaea.

Associates: Bulbophyllum pecten-veneris, Bulbophyllum psychoon, Bulbophyllum ssp., Cleisostoma striatum, Cleisostoma williamsonii, Coelogyne ssp., Cymbidium ssp., Dendrobium nobile, Eria apertiflora, Huperzia sp., Liparis pumila, Liparis viridiflora, Luisia ssp., Luisia zollingeri, Lycopodium sp., Oberonia falconeri, Oberonia ssp., Ornithochilus difformis, Panisea ssp., Stereochilus brevirachis, Sunipia scariosa, Thrixspermum stelidioides, Trichotosia microphylla, Trichotosia pulvinata, Vanda sp.

Lithophytes:

Dominants: Asplenium rupestre, Carex sp., Eria carinata, Eria globulifera, Eria siamensis, Flickingeria fimbriata, Liparis viridiflora, Pyrrosia ssp.

Associates: *Appendicula hexandra*, *Argostemma* ssp., *Asplenium* sp., *Boea* ssp., *Chirita* ssp., *Cymbidium lowianum*, *Didymocarpus* sp., *Eria bambusifolia*, *Hedychium* sp., *Hedychium yunnanense*, *Hedyotis* ssp., *Lilium poilanei*, *Oreocharis argyrophylla*, *Oreocharis blepharophylla*, *Oreocharis* sp., *Paraboea* sp., *Vittaria elongata*.

Climbers & lianas:

Dominants: no certain dominants

Associates: *Dioscorea* sp., *Smilax* sp., *Tetrastigma* sp.

Riparian and subaquatic plants of specific life forms:

no

Plants of specific life forms:

no

5. Evergreen ericaceous montane scrub

Summarized data based on vegetation descriptions

Date: September - October 2016. Made by Averyanov L. et al.

Position: Northern Vietnam, Son La province, Pha Luong Mountains 20°40'00'' – 20°42'50''N, 104°36'30'' – 104°41'40''E.

Elevation: (1500)1700-1860 m. Slope exposition W, N, E & S. Slope inclination 0-70(90)°.

Parental soil material: solid red-brown sandstone.

Leaf litter: 0-3 cm thick with projected coverage 0-100%.

Soil: thin, with brown humus-containing horizon (0)1-3(5) cm.

Zonal (elevational) plant community: Evergreen ericaceous montane scrub.

Plant community structure:

1 stratum (treelet & shrub storey):

Height in m.	Diameter (in cm at BH)	Projective coverage in %.
1.5-2(3)	(1)3-10(15)	(30)40-90(100)

Dominants: *Gaultheria fragrantissima*, *Gaultheria* sp., *Ilex* sp., *Leucothoe* sp., *Lyonia ovalifolia*, *Lyonia* ssp., *Rhododendron* ssp., *Vaccinium* ssp.

Associates: *Eriobotrya* sp., *Fokienia hodginsii*, *Hypericum hookerianum*, *Lithocarpus* ssp., *Melastoma* sp., *Myrsine* sp., *Photinia cucphuongensis*, *Podocarpus neriifolius*, *Psychotria* ssp., *Quercus* sp., *Schefflera* sp., *Viburnum* sp.

2 stratum (herbs):

Height in m.	Projective coverage in %.
0.03-1(1.5)	(0)5-10(15)

Dominants: *Carex* sp., *Diplasium* sp., *Elatostema* ssp., *Pellionia* ssp., *Polystichum* sp., *Scleria* sp., *Selaginella* sp.

Associates: *Calanthe alleizettii*, *Collabium chinense*, *Cymbidium ensifolium*, *Cymbidium lancifolium*, *Goodyera schlechtendaliana*, *Sonerila* ssp., *Tainia* sp., *Zeuxine nervosa*.

3 stratum (mosses & lichens):

Height in cm.	Projective coverage in %.
(0.1)0.5-3	(10)30-60(90)

Dominants: Bryophytes and lichens undeterm.

Associates: *Cladonia* ssp., *Polytrichum* ssp., Bryophytes and lichens undeterm.

Non strata vegetation:

Epiphytes & semi-epiphytes:

Dominants: no certain dominants

Associates: *Bulbophyllum ambrosia*, *Bulbophyllum psychoon*, *Bulbophyllum reptans*, *Bulbophyllum* ssp., *Ceratostylis himalaica*, *Cleisostoma williamsonii*, *Coelogyne* ssp., *Davallia* sp., *Dendrobium nobile*, *Epigeneium chapaense*, *Huperzia* sp., *Lepisorus* sp., *Liparis viridiflora*, *Lycopodium* sp., *Microsorium* sp., *Pyrrosia* sp., *Thelasis pygmaea*.

Lithophytes:

Dominants: no certain dominants.

Associates: *Asplenium* sp., *Carex* sp., *Chirita* ssp., *Cymbidium lowianum*, *Eria bambusifolia*, *Eria carinata*, *Eria globulifera*, *Eria siamensis*, *Hedychium yunnanense*, *Hedyotis* ssp., *Lilium poilanei*, *Liparis viridiflora*, *Oreocharis argyrophylla*, *Oreocharis blepharophylla*, *Pyrrosia* ssp.

Climbers & lianas:

Dominants: no certain dominants

Associates: *Dioscorea* sp., *Smilax* sp., *Tetrastigma* sp.

Riparian and subaquatic plants of specific life forms:

no

Plants of specific life forms:

no

6. Bamboo montane thickets

Summarized data based on vegetation descriptions

Date: September - October 2016. Made by Averyanov L. et al.

Position: Northern Vietnam, Son La province, Pha Luong Mountains 20°40'00'' – 20°42'50''N, 104°36'30'' – 104°41'40''E.

Elevation: (1500)1700-1860 m. Slope exposition W, N, E & S. Slope inclination 0-70(90)°.

Parental soil material: solid red-brown sandstone.

Leaf litter: 0-3 cm thick with projected coverage 0-100%.

Soil: thin, with brown humus-containing horizon (0)1-3(5) cm.

Azonal plant community: Bamboo montane thickets.

Plant community structure:

1 stratum (treelet & shrub storey):

Height in m.	Diameter (in cm at BH)	Projective coverage in %.
1-2(2.5)	0.5-1(1.5)	(25)50-80(100)

Dominants: Undeterm. bamboo (Poaceae Bambusoideae, Arundinaria aff.).

Associates: Eriobotrya sp., Gaultheria fragrantissima, Gaultheria sp., Ilex sp., Leucothoe sp., Lithocarpus ssp., Lyonia ovalifolia, Lyonia ssp., Myrsine sp., Photinia cucphuongensis, Podocarpus neriifolius, Psychotria ssp., Quercus sp., Rhododendron ssp., Schefflera sp., Viburnum sp.

2 stratum (herbs):

Height in m.	Projective coverage in %.
0.03-1	(0)5-10(15)

Dominants: no certain dominants.

Associates: Calanthe alleizettii, Carex sp., Collabium chinense, Cymbidium ensifolium, Cymbidium lancifolium, Diplasium sp., Elatostema ssp., Goodyera schlechtendaliana, Polystichum sp., Scleria sp., Selaginella sp., Tainia sp., Zeuxine nervosa.

3 stratum (mosses & lichens):

Height in cm.	Projective coverage in %.
(0.1)0.5-3	(10)20-40(60)

Dominants: Bryophytes and lichens undeterm.

Associates: Polytrichum ssp., Bryophytes and lichens undeterm.

Non strata vegetation:

Epiphytes & semi-epiphytes:

Almost absent.

Lithophytes:

Dominants: no certain dominants.

Associates: Asplenium sp., Carex sp., Hedychium yunnanense, Hedyotis ssp., Lilium poilanei, Pyrrosia ssp.

Climbers & lianas:

Dominants: no certain dominants

Associates: Dioscorea sp., Smilax sp., Tetrastigma sp.

Riparian and subaquatic plants of specific life forms:

no

Plants of specific life forms:

no

7. Sphagnum-herbaceous montane grassland

Summarized data based on vegetation descriptions

Date: September - October 2016. Made by Averyanov L. et al.

Position: Northern Vietnam, Son La province, Pha Luong Mountains 20°40'00'' – 20°42'50''N, 104°36'30'' – 104°41'40''E.

Elevation: 1800-1860 m. Slope exposition W, N, E & S. Slope inclination 0-10(15)°.

Parental soil material: solid red-brown sandstone.

Leaf litter: 0-1 cm thick with projected coverage 0-5(10)%.

Soil: very thin, (0)1-3(5) cm thick, to almost absent, or with few thin turf deposits.

Azonal plant community: Sphagnum-herbaceous montane grassland.

Plant community structure:

1 stratum (herbs):

Height in m.	Projective coverage in %.
0.03-1(1.5)	(5)15-55(70)

Dominants: Carex sp., Cyperus sp., Hedychium sp., Hedychium yunnanense, Melastoma sp., Scleria sp., Selaginella sp., Xyris indica, Xyris sp.

Associates: Ainsliaea sp., Anemone sp., Anthogonium gracile, Blumea sp., Cyanotis sp., Drosera peltata, Hypericum hookerianum, Impatiens sp., Lilium poilanei, Lysimachia sp., Sedum sp., Strobilanthes sp., Strobilanthes taoana, Clematis sp.

2 stratum (mosses & lichens):

Height in cm.	Projective coverage in %.
(0.1)0.5-5(10)	(10)30-50(100)

Dominants: Sphagnum sp., Bryophytes and lichens undeterm.

Associates: Sphagnum ssp., Cladonia ssp., Polytrichum ssp., Bryophytes and lichens undeterm.

Non strata vegetation:

Epiphytes & semi-epiphytes:

no

Lithophytes:

Almost all observed plant species.

Climbers & lianas:

Dominants: no certain dominants

Associates: Ampelopsis sp., Crowfurdia sp., Dioscorea sp., Smilax ssp.

Tetrastigma sp.

Riparian and subaquatic plants of specific life forms:

no

Plants of specific life forms:

no

Non strata vegetation:

Epiphytes more or less common in all kind of plant communities in Pha Luong Mountains:

Lycopodiaceae

Huperzia sp.
Lycopodium sp.

Polypodiaceae s.l.

Davallia sp.
Drynaria sp.
Lemmaphyllum microphyllum
Lepisorus sp.
Microsorium sp.
Pyrrhosia sp.

Asclepiadaceae

Dischidia sp.
Hoya sp.

Gesneriaceae

Aeschynanthus mendumiaiae
Aeschynanthus ssp.
Lysionotus chingii
Peperomia sp.

Orchidaceae

Bulbophyllum ambrosia
Bulbophyllum apodum
Bulbophyllum biesetoides
Bulbophyllum pecten-veneris

Bulbophyllum psychoon
Bulbophyllum reptans
Bulbophyllum ssp.
Callostylis rigida
Ceratostylis himalaica
Cleisostoma striatum
Cleisostoma williamsonii
Coelogyne fimbriata
Coelogyne ssp.
Cymbidium lowianum
Cymbidium ssp.
Dendrobium brymerianum
Dendrobium chrysanthum
Dendrobium eriiflorum
Dendrobium falconeri
Dendrobium fimbriatum
Dendrobium hancockii
Dendrobium jenkinsii
Dendrobium nobile
Dendrobium spatella
Dendrobium thyrsoiflorum
Epigeneium amplum
Epigeneium chapaense
Eria apertiflora
Eria calcarea
Eria pannea
Eria rhomboidalis

Eria siamensis
Eria thao
Eria ssp.
Hygrochilus parishii
Liparis longispica
Liparis pumila
Liparis viridiflora
Luisia zollingeri
Luisia ssp.
Oberonia falconeri
Oberonia ssp.
Ornithochilus difformis
Panisea ssp.
Pholidota articulata
Pholidota chinensis
Pholidota recurva
Smitinandia helferi
Stereochilus brevirachis
Sunipia scariosa
Tainia latifolia
Thelasis pygmaea
Thrixspermum centipeda
Thrixspermum stelioides
Trichotomia microphylla
Trichotomia pulvinata
Vanda sp.

Non strata vegetation:

Lithophytes more or less common in all kind of plant communities in Pha Luong Mountains:

Polypodiaceae s.l.

Antrophyum sp.
Asplenium antrophioides
Asplenium rupestre
Asplenium sp.
Aglamorpha acuminata
Vittaria elongata
Vittaria hainanensis
Vittaria sp.

Cyperaceae

Carex sp.
Scleria sp.

Gesneriaceae

Boea ssp.
Chirita ssp.
Didymocarpus sp.
Oreocharis argyrophylla
Oreocharis blepharophylla
Oreocharis sp.

Paraboea sp.
Rhynchotechum sp.
Streptocarpus sp.

Liliaceae

Lilium poilanei

Melastomataceae

Sonerila ssp.

Piperaceae

Peperomia sp.

Rubiaceae

Argostemma ssp.
Hedyotis ssp.

Zingiberaceae

Hedychium yunnanense
Hedychium sp.

Orchidaceae

Appendicula hexandra
Collabium chapaensis
Collabium chinense
Cymbidium lowianum
Eria bambusifolia
Eria calcarea
Eria carinata
Eria corneri
Eria globulifera
Eria rhomboidalis
Eria siamensis
Flickingeria fimbriata
Liparis averyanoviana
Liparis balansae
Liparis bootanensis
Liparis dendrochiloides
Liparis superposita
Liparis viridiflora

Appendix 2

Appendix 2.

Observed and collected plant species

Plants collected by L.Averyanov, N.T.Hiep, N.S.Khang, N.D.Thang and L.D.Qui during 12 – 17 November 2013 (collection numbers of voucher herbarium specimens – CPC 6960 – 7251) and collected by L.Averyanov, N.T.Hiep, N.S.Khang, C.Q.Ngan, T.V.Maisak and N.T.Son during 22 September – 2 October 2016 (collection numbers of voucher herbarium specimens – CPC 7910 – 8241).

Remarks: * – new record for Vietnam; ** – local endemic; *** – new species for science.

Lycopodiophyta (Lycopods)

Lycopodiaceae

Huperzia sp.1 CPC 8021
Huperzia sp.2 CPC 8215
Lycopodium sp. CPC 8071

Selaginellaceae

Selaginella sp.1 CPC 6974
Selaginella sp.2 CPC 7148
Selaginella sp.3 CPC 7193
Selaginella sp.4 CPC 7207
Selaginella sp.5 CPC 7215
Selaginella sp.6 CPC 7244

Pteridophyta (Ferns)

Hymenophyllaceae

Crepidomanes auriculatum (Blume) K.Iwats. CPC 7142, CPC 8148
Mecodium sp. CPC 7039
Trichomenes sp. CPC 6971

Marattiaceae

Angiopteris evecta (G.Forst.) Hoffm. CPC 7159

Polypodiaceae s.l.

Adiantum capillus-veneris L. CPC 7225 photos
Adiantum caudatum L. CPC 7096
Aglamorpha acuminata (Willd.) C.V.Morton CPC 8096 photos
Antrophyum sp. CPC 7056
Asplenium antrophioides Christ. CPC 7179, CPC 7071
Asplenium rupestre Hope CPC 7099, CPC 7210
Asplenium sp.1 CPC 7069
Asplenium sp.2 CPC 7125
Asplenium sp.3 CPC 7130
Asplenium sp.4 CPC 7145
Asplenium sp.5 CPC 7178
Asplenium sp.6 CPC 8006
Bolbithis sp. CPC 7155
Colysis sp. CPC 7147
Cyrptomium sp. CPC 7150
Davallia sp. CPC 7024
Diplazium donianum (Mett.) Tardieu CPC 7131
Diplasium sp.1 CPC 7034
Diplasium sp.2 CPC 7124
Diplazium sp.3 CPC 7132
Diplazium sp.4 CPC 7138
Drynaria sp. CPC 8058
Lemmaphyllum microphyllum C.Presl CPC 7065
Lepisorus sp.1 CPC 7093
Lepisorus sp.2 CPC 7163
Leptochoylus sp.1 CPC 7036
Leptochoylus sp.2 CPC 7144
Lindsaea orbiculata (Lam.) Kuhn CPC 6961
Loxogramme sp. CPC 7051
Microlepidia sp.1 CPC 7110

Microlepidia sp.2 CPC 7113
Microlepidia sp.3 CPC 7180
Microsorium sp.1 CPC 7066
Microsorium sp.2 CPC 7149
Plagiogyria sp. CPC 7037
Polystichum sp.1 CPC 6970
Polystichum sp.2 CPC 7073
Polystichum sp.3 CPC 7100
Polystichum sp.4 CPC 7120
Polystichum sp.5 CPC 7123
Polystichum sp.6 CPC 8149
Polystichum sp.7 CPC 8212
Pteris sp.1 CPC 7063
Pteris sp.2 CPC 7192
Pteris sp.3 CPC 7202
Pteris sp.4 CPC 7203
Pyrrosia sp.1 CPC 7047
Pyrrosia sp.2 CPC 7055
Pyrrosia sp.3 CPC 7112
Pyrrosia sp.4 CPC 7214
Tectaria sp. CPC 7133
Thelypteris sp. CPC 7154
Vittaria elongata Sw. CPC 7918 ass. photos
Vittaria hainanensis Ching CPC 7919, CPC 8002 photos
Vittaria sp. CPC 7170

Cycadophyta (Cycads)

Cycadaceae

Cycas collina K.D.Hill et al.** CPC 7251, CPC 7240 photos

Pinophyta (Conifers)

Cupressaceae

Calocedrus rupestris Aver. et al.** CPC 8095, CPC 8225
Fokienia hodginsii (Dunn) A.Henry & H.H.Thomas CPC 7032, CPC 7929, CPC 8014, CPC 8018 photos, CPC 8174

Pinaceae

Keteleeria evelyniana Mast. CPC 8118
Pinus cernua Aver. et al.** CPC 6992, CPC 7959, CPC 8013, CPC 8019, CPC 8022, CPC 8107, CPC 8169 photos
Pinus wangii Hu & W.C.Cheng CPC 8236 photos

Podocarpaceae

Dacrycarpus imbricatus (Blume) de Laub. CPC 7164, CPC 8027
Podocarpus neriifolius D.Don CPC 6969, CPC 7031, CPC 7168, CPC 7223, CPC 8062, CPC 7933
Podocarpus pilgeri Foxw. CPC 8234

Taxaceae

Taxus wallichiana Zucc. CPC 8224

Magnoliophyta (Flowering plants)

Acanthaceae

Justicia sp. CPC 8227

Strobilanthes taoana Y.F.Deng & J.R.I.Wood CPC 7979 photos

Strobilanthes sp.1 CPC 7115

Strobilanthes sp.2 CPC 8043

Gen.sp.1 CPC 7190

Gen.sp.2 CPC 7222

Gen.sp.3 CPC 8064

Gen.sp.4 CPC 8157 photos

Gen.sp.5 CPC 8177

Aceraceae

Acer sp.1 CPC 8101

Acer sp.2 CPC s.n., 7984 ass.

Actinidiaceae

Actinidia sp. CPC 7982

Anacardiaceae

Pistacia weinmanniifolia Franch. CPC 7238, CPC 8233

Spondias sp. CPC s.n., 7984 ass.

Gen.sp. CPC 7086

Annonaceae

Alphonsea sp. CPC 8165

Artobotrys sp. CPC 6979

Popovia sp. CPC 6967

Gen.sp.1 CPC 7185

Gen.sp.2 CPC 8113

Apocynaceae

Alyxia sp.1 CPC 7084

Alyxia sp.2 CPC 8065

Melodinus sp. CPC 8208

Gen.sp.1 CPC 8072

Gen.sp.2 CPC 8124

Aquifoliaceae

Ilex sp.1 CPC 8170

Ilex sp.2 CPC 7967

Araceae

Scindapsus sp. CPC 8168

Araliaceae

Schefflera sp.1 CPC 7092

Schefflera sp.2 CPC 7915 photos

Schefflera sp.3 CPC 7972

Schefflera sp.4 CPC 8068

Schefflera sp.5 CPC 8205

Trevesia vietnamensis J.Wen & P.K.Loc** CPC 7146

Arecaceae

Licuala sp. CPC 7135

Livistona chinensis (Jacq.) Mart. CPC s.n., 7984 ass.

Pinanga sp. CPC 7141

Rhapis sp.1 CPC 7062

Rhapis sp.2 CPC 7211

Trachycarpus geminisetus Spanner & al.** CPC 8209

Asclepiadaceae

Dischidia sp. CPC 8106

Hoya lyi H.Lev.* CPC 8105, CPC 8236/1

Hoya parasitica Traill. CPC 8103

Hoya sp.1 CPC 8104

Hoya sp.2 CPC 8123d

Hoya sp.3 CPC 8123e

Hoya sp.4 CPC 8123f

Asteraceae

Ainsliaea sp.1 CPC 7986

Ainsliaea sp.2 CPC 8003

Blumea sp.1 CPC 7184

Blumea sp.2 CPC 8074

Balanophoraceae

Balanophora laxiflora Hemsl. CPC 7938

Balanophora sp. CPC 7188

Balsaminaceae

Impatiens sp.1 CPC 7136

Impatiens sp.2 CPC 7952

Impatiens sp.3 CPC 8035

Impatiens sp.4 CPC 8213

Begoniaceae

Begonia delavayi Gagnep. CPC 7219, CPC 8217

Begonia handelii Irmsch. CPC 8180

Begonia hemsleyana Hook.f. CPC 7157, CPC 7913, CPC 8152

Begonia howii Merr. & Chun CPC 7122, CPC 7917

Begonia phaluongense sp. nov.*** CPC 7962

Begonia tetragona Irmsch. CPC 8183

Begonia sp.1 CPC 7109

Begonia sp.2 CPC 7953

Begonia sp.3 CPC 8131

Begonia sp.4 CPC 8179

Begonia sp.5 CPC 8207

Betulaceae

Carpinus viminea Lindl. CPC 8061, CPC 8226

Burmanniaceae

Burmannia indica Jonker CPC 8030

Burmannia sp. CPC 8241

Campanulaceae

Codonopsis javanica (Blume) Hook.f. & Thomson CPC 8042

Caprifoliaceae

Sambucus javanica Blume CPC 7152

Viburnum sp.1 CPC 8112

Viburnum sp.2 CPC 8178

Carlemoniaceae

Silvianthus tonkinensis (Gagnep.) Ridsdale CPC 8185

Celastraceae

Glyptopetalum sp. CPC 8211

Chloranthaceae

Chloranthus sp. CPC 7980

Sarcandra glabra (Thunb.) Nakai CPC 7016, CPC 7121

Commelinaceae

Cyanotis sp. CPC 7182

Spatholirion puluogense Aver.** CPC 7918 photos

Streptolirion volubile Edgew. CPC 7114

Convallariaceae

Aspidistra ambigua sp. nov.*** CPC 8167

Aspidistra bifolia Aver., Tillich & K.S.Nguyen, sp. nov.*** CPC 8057 photos

Aspidistra nutans Aver. & Tillich*** CPC 7158a, CPC 8155, CPC 7912 photos

Aspidistra subrotata Y.Wan & C.C.Huang CPC 6962, CPC 6963, CPC 7161

Aspidistra sp. CPC 8136
Disporum sp. CPC 8120 photos
Ophiopogon alatus Aver. & N.Tanaka*** type CPC 7070a photos
Ophiopogon bockianus Diels* CPC 8076 photos.
Ophiopogon intermedius D.Don CPC 7996 photos
Ophiopogon tonkinensis L.Rodr CPC 7166, CPC 7911 photos
Ophiopogon sp.1 CPC 7126
Ophiopogon sp.2 CPC 7217
Ophiopogon sp.3 CPC 8010
Ophiopogon sp.4 CPC 8011
Ophiopogon sp.5 CPC 8041
Ophiopogon sp.6 CPC 8057b
Ophiopogon sp.7 CPC 8116
Ophiopogon sp.8 CPC 8151
Peliosanthes griffithii Baker CPC 6962a photos, CPC 7947, CPC 8154
Peliosanthes kenhilloides Aver. et N.Tanaka*** type CPC 7223a photos
Peliosanthes sp.1 CPC 7017
Peliosanthes sp.2 CPC 8236/12
Polygonatum sp. CPC 7992
Tupistra khangii Aver. et al.*** CPC 7158, CPC 7955 photos
Tupistra sp.1 CPC 8057c
Tupistra sp.2 CPC 8236/11

Convolvulaceae

Argyraea sp. CPC 7200
Merremia sp. CPC 8121
Gen.sp. CPC 7052

Cornaceae

Diplopanax vietnamensis Aver. & T.H.Nguyen** CPC s.n., 7984 ass.

Crassulaceae

Sedum sp. CPC 7995

Cucurbitaceae

Trichosanthes sp.1 CPC 7183
Trichosanthes sp.2 CPC 8159

Cyperaceae

Carex sp. CPC 7216
Cyperus sp. CPC 7977
Scleria sp.1 CPC 7006
Scleria sp.2 CPC 7988

Dioscoreaceae

Dioscorea sp.1 CPC 7946
Dioscorea sp.2 CPC 7971

Droseraceae

Drosera peltata Thunb. CPC 7965, CPC 7998 photos

Ebenaceae

Diospyros sp. CPC 8114

Ericaceae

Gaultheria fragrantissima Wall. CPC 7974
Gaultheria sp. CPC 7924
Leucothoe sp. CPC 8005
Lyonia ovalifolia (Wall.) Drude CPC 7930
Lyonia sp.1 CPC 7007
Lyonia sp.2 CPC 7046
Lyonia sp.3 CPC 7973
Lyonia sp.4 CPC 8133
Rhododendron sp.1 CPC 6985
Rhododendron sp.2 CPC 6997

Rhododendron sp.3 CPC 7030
Rhododendron sp.4 CPC 7925
Rhododendron sp.5 CPC 7935
Rhododendron sp.6 CPC 7975
Rhododendron sp.7 CPC 8029
Vaccinium sp.1 CPC 7087
Vaccinium sp.2 CPC 7090
Vaccinium sp.3 CPC 7926
Vaccinium sp.4 CPC 7931
Vaccinium sp.5 CPC 8098
Vaccinium sp.6 CPC 8236/7

Euphorbiaceae

Antidesma sp. CPC 8163
Croton sp. CPC 7201
Gen.sp. CPC 8122

Fabaceae

Ormosia sp.1 CPC 8186
Ormosia sp.2 CPC 8219
Phylacium majus Collett & Hemsl.* CPC 7226

Fagaceae

Castanopsis sp.1 CPC 7990
Castanopsis sp.2 CPC s.n., 7984 ass.
Lithocarpus sp.1 CPC 8008
Lithocarpus sp.2 CPC s.n., 7984 ass.
Quercus sp.1 CPC 7927 photos
Quercus sp.2 CPC 8093
Quercus sp.3 CPC 8094

Gentianaceae

Crowfordtia sp. CPC 7964

Gesneriaceae

Aeschynanthus mendumiae D.J.Middleton CPC 7045, CPC 7162
Aeschynanthus sp.1 CPC 7064
Aeschynanthus sp.2 CPC 8007
Aeschynanthus sp.3 CPC 8054
Aeschynanthus sp.4 CPC 8066
Aeschynanthus sp.5 CPC 8138
Aeschynanthus sp.6 CPC 8236/4
Boea sp.1 CPC 8067
Boea sp.2 CPC 8075
Boea sp.3 CPC 8109
Calcareoboena coccinea C.Y.Wu** CPC 8235 photos.
Chirita sp.1 CPC 7035
Chirita sp.2 CPC 7053
Chirita sp.3 CPC 7156
Chirita sp.4 CPC 7209
Chirita sp.5 CPC 7914
Chirita sp.6 CPC 7954
Chirita sp.7 CPC 7991
Chirita sp.8 CPC 8024
Chirita sp.9 CPC 8150
Didymocarpus sp. CPC 7940
Lysionotus chingii Chun ex W.T.Wang** CPC 8156 photos
Oreocharis argyrophylla W.H.Chen et al.*** CPC 7020, CPC 7175, CPC 7939, CPC 7993, CPC 8173 photos
Oreocharis blepharophylla W.H.Chen et al.*** CPC 7019 CPC 8000, CPC 8171 photos
Oreocharis sp. CPC 8026
Paraboena sp. CPC 8210
Rhynchotechum sp. CPC 8158
Streptocarpus sp. CPC 8036
Gen.sp. CPC 6998
Gen.sp. CPC 8137

Hamamelidaceae

Liquidambar formosana Hance CPC 7008

Hernandiaceae

Illigera sp. CPC 7221

Hypericaceae

Hypericum hookerianum Wight & Arn. CPC 7981

Juglandaceae

Platycarya strobilacea Siebold & Zucc. CPC 7102, CPC 8237

Lamiaceae

Leonurus sp. CPC 7227

Ocimum sp. CPC 7197

Gen.sp.1 CPC 7116

Gen.sp.2 CPC 7224

Gen.sp.3 CPC 7239

Lauraceae

Cinnamomum sp.1 CPC 7984

Cinnamomum sp.2 CPC s.n., 7984 ass.

Cinnamomum sp.3 CPC 8070

Litsea sp.1 CPC 7989

Litsea sp.2 CPC s.n., 7984 ass.

Gen.sp.1 CPC 7004

Gen.sp.2 CPC 8037

Liliaceae

Chlorophytum sp. CPC 8057a

Lilium poilanei Gagnep.** CPC 7978, CPC 8216 photos

Linaceae

Tirpitzia sinensis (Hemsl.) Hallier f. CPC 7085, CPC 8238

Magnoliaceae

Magnolia foveolata (Dandy) Figlar CPC 7928, CPC 7960

Magnolia megaphylla (Hu & W.C.Cheng) V.S.Kumar CPC 7920,
CPC 8132 photos

Magnolia sp. CPC 7021

Manglietia dandyi (Gagnep.) Dandy CPC 6978

Michelia balansae (A.DC.) Dandy CPC 7921

Michelia sp.1 CPC 7022

Michelia sp.2 CPC 7040

Michelia sp.3 CPC 7189

Parakmeria robusta (B.L.Chen & Noot.) Q.N.Vu & N.H.Xia CPC
7961 photos

Malpighiaceae

Hyptage sp. CPC 7091

Melastomataceae

Blastus sp.1 CPC 7140

Blastus sp.2 CPC 8161

Medinilla sp. CPC 7181

Melastoma sp. CPC 7987 photos

Oxyspora sp.1 CPC 6965

Oxyspora sp.2 CPC 7177

Phyllagathis pulchella sp. nov.*** CPC 7910 photos

Phyllagathis sp. CPC 8153

Sonerila sp.1 CPC 7005

Sonerila sp.2 CPC 7044

Sonerila sp.3 CPC 7171

Sonerila sp.4 CPC 7950

Sonerila sp.5 CPC 8172

Gen.sp. CPC 7963

Meliaceae

Aglaia sp.1 CPC 8117

Aglaya sp.2 CPC 8160

Menispermaceae

Gen.sp. CPC 7948

Moraceae

Ficus gibbosa Blume CPC 7095

Myrsinaceae

Ardisia sp.1 CPC 6975

Ardisia sp.2 CPC 7129

Ardisia sp.3 CPC 7134

Ardisia sp.4 CPC 7169

Ardisia sp.5 CPC 7174

Ardisia sp.6 CPC 8164

Myrsine sp. CPC 6996

Orchidaceae

Anoectochilus annamensis Aver.** CPC 7175a

Anoectochilus roxburghii (Wall.) Lindl. CPC 8147, CPC 8176

Anthogonium gracile Wall. ex Lindl. CPC 7997

Apostasia wallichii R.Br. CPC 8146

Appendicula hexandra (Koenig) J.J.Smith CPC 6982

Bulbophyllum ambrosia (Hance) Schltr. CPC 7107

Bulbophyllum andersonii (Hook.f.) J.J.Sm. CPC 7080 photos

Bulbophyllum apodum Hook.f. CPC 7246

Bulbophyllum biesetoides Seidenf. CPC 6981 photos

Bulbophyllum macraei (Lindl.) Rchb.f. CPC 7249

Bulbophyllum pecten-veners (Gagnep.) Seidenf. CPC 7012

Bulbophyllum psychoon Rchb.f. CPC 8196

Bulbophyllum reptans (Lindl.) Lindl. CPC 7028, CPC 8144

Bulbophyllum violaceolabellum Seidenf.** CPC 8033

Bulbophyllum xylophyllum Par. & Rchb.f. CPC 7088

Bulbophyllum sp.1 CPC 6991

Bulbophyllum sp.2 CPC 7012a

Bulbophyllum sp.3 CPC 7173

Bulbophyllum sp.4 (Desmosanthae sect.) CPC 8190

Bulbophyllum sp.5 CPC 8034

Bulbophyllum sp.6 CPC 8087

Bulbophyllum sp.7 CPC 8123b

Bulbophyllum sp.8 CPC 8123c

Calanthe alleizettii Gagnep. CPC 8200**

Calanthe clavata Lindl. CPC 8028

Calanthe densiflora Lindl. CPC 7014, CPC 7176

Calanthe puberula Lindl.* CPC 7999 photos

Calanthe sylvatica (Thouars) Lindl. CPC 8199

Calanthe sp. CPC 7165

Callostylis rigida Blume CPC 7106, CPC 7232

Ceratostylis himalaica Hook.f. CPC 7082, CPC 8142

Cheirostylis takeoi (Hayata) Schltr. CPC 7208a

Cheirostylis sp. CPC 8040a

Cleisostoma striatum (Rchb.f.) Garay CPC 7187, CPC 8088

Cleisostoma williamsonii (Rchb.f.) Garay CPC 7198, CPC 8126

Coelogyne fimbriata Lindl. CPC 7027, CPC 7089, CPC 7241, CPC
8015, CPC 8085, CPC 8231

Coelogyne sp.1 CPC 7245

Coelogyne sp.2 CPC 8083

Collabium chapaensis (Gagnep.) Seidenf. & Ormerod** CPC 7011
photos

Collabium chinense (Rolfe) Tang & F.T.Wang CPC 8001, CPC 8141

Cymbidium ensifolium (L.) Sw. CPC 7042, CPC 7167, CPC 8025,
CPC 8077, CPC 8228

Cymbidium kanran Makino* CPC 6984 photos

Cymbidium lancifolium Hook. CPC 7075, CPC 7230, CPC 8230

Cymbidium lowianum (Rchb.f.) Rchb.f. CPC 7038, CPC 7923
photos
Cymbidium sp. CPC 8236/3
Dendrobium brymerianum Rchb.f. CPC 8020, CPC 8140
Dendrobium chrysanthum Lindl. CPC 8108 photos, CPC 8082
Dendrobium eriiflorum Griff. CPC 8053 photos
Dendrobium falconeri Hook.f. CPC 8031
Dendrobium fimbriatum Hook. CPC 8055
Dendrobium hancockii Rolfe CPC 8197
Dendrobium jenkinsii Wall. ex Lindl. CPC 8051
Dendrobium nobile Lindl. CPC 7958
Dendrobium spatella Rchb.f. CPC 6983, CPC 7081, CPC 8084, CPC
8125
Dendrobium thyrsoflorum B.S.Williams CPC 8023
Didymoplexis pallens Griff. CPC 7186
Epigeneium amplum (Lindl.) Summerh. CPC 6987, CPC 7247, CPC
7956, CPC 8016, CPC 8086, CPC 8187
Epigeneium chapaense Gagnep.** CPC 7025, CPC 7957, CPC 8143,
CPC 8232 photos
Eria apertiflora Summerh. CPC 8045 photos
Eria bambusifolia Lindl. CPC 6988
Eria calcarea V.N.Long & Aver.** CPC 8048
Eria carinata Lindl. CPC 6995 photos
Eria corneri Rchb.f. CPC 7941
Eria coronaria (Lindl.) Rchb.f. CPC 8080, CPC 8195
Eria globulifera Seidenf. CPC 7098
Eria pachyphylla Aver.** CPC 7076, CPC 7235
Eria pannea Lindl. CPC 8052
Eria rhomboidalis Tang & F.T.Wang CPC 7074
Eria siamensis Schltr. CPC 7026, CPC 7944, CPC 8192 photos
Eria thao Gagnep.** CPC 6990, CPC 7078
Eria sp.1 CPC 8188
Eria sp.2 CPC 8236/2
Eriodes barbata (Lindl.) Rolfe** CPC 8044 photos
Flickingeria fimbriata (Blume) Hawkes CPC 7072
Gastrodia khangii Aver., sp. nov.*** CPC 8240 photos
Geodorum sp. CPC 6961a
Goodyera foliosa (Lindl.) C.B.Clarke CPC 8145
Goodyera schlechtendaliana Rchb.f. CPC 7942, CPC 8032
Habenaria medioflexa Turrill** CPC 6960
Habenaria sp. CPC 8198
Hygrochilus parishii (Veitch & Rchb.f.) Pfitzer CPC 8012
Lecanorchis vietnamica Aver.** CPC 8139
Liparis averyanoviana Szlach.** CPC 7033, CPC 7061, CPC 7923a,
CPC 8202
Liparis balansae Gagnep.** CPC 8009, CPC 8017 photos
Liparis bootanensis Griff. CPC 7151
Liparis dendrochiloides Aver.** CPC 7083
Liparis distans C.B.Clarke CPC 7057, CPC 8194
Liparis longispica Aver. et K.S.Nguyen*** Type CPC 7043 photos
Liparis mannii Rchb.f. CPC 7058, CPC 7248
Liparis nervosa (Thunb.) Lindl. CPC 6973
Liparis pumila Aver.** CPC 8046
Liparis superposita Ormerod** CPC 8090
Liparis viridiflora (Blume) Lindl. CPC 7199
Luisia zollingeri Rchb.f. CPC 7077
Luisia sp.1 CPC 8081
Luisia sp.2 CPC 8115
Monomeria barbata Lindl. CPC 7000, CPC 7023, CPC 8193, CPC
8236/5
Nervilia aragoana Gaudich. CPC 8040
Oberonia ensiformis (J.E.Smith) Lindl. CPC 7060, CPC 7231, CPC
8191
Oberonia falconeri Hook.f. CPC 7079
Oberonia sp.1 CPC 8092
Oberonia sp.2 CPC 8092a
Ornithochilus difformis (Lindl.) Schltr. CPC 7103, CPC 8047

Panisea sp.1 CPC 8078
Panisea sp.2 CPC 8236/10
Paphiopedilum concolor (Batem.) Pfitzer CPC 7208
Paphiopedilum dianthum Tang & F.T.Wang CPC 8056
Paphiopedilum hirsutissimum (Lindl.) Stein CPC 7059, CPC 7234,
CPC 8073
Paphiopedilum malipoense S.C.Chen et Tsi CPC 7070
Pelatantheria insectifera (Rchb.f.) Ridl. CPC 7097, CPC 8123
Pholidota articulata Lindl. CPC 6999, CPC 7250, CPC 6986
Pholidota chinensis Lindl. CPC 7233, CPC 7943
Pholidota missionariorum Gagnep. CPC 7105
Pholidota recurva Lindl. CPC 7101, CPC 8079
Pholidota yunnanensis Rolfe CPC 7945, CPC 8050, CPC 8189
Podochilus khasianus Hookf. CPC 7068, CPC 7242, CPC 8206
Podochilus oxystophylloides Ormerod.** CPC 7067, CPC 7243,
CPC 8091
Rhomboda petelotii (Gagnep.) Ormerod** CPC 8236/9
Smitinandia helferi (Hook.f.) Garay* CPC 8049
Stereochilus brevirachis Christenson* CPC 8047a
Sunipia andersonii (King & Pantl.) P.F.Hunt CPC 8203, CPC 8236/6
Sunipia scariosa Lindl. CPC 8201
Tainia latifolia (Lindl.) Rchb.f. CPC 6964
Thelasis pygmaea (Griff.) Blume CPC 7094, CPC 8089
Thrixspermum centipeda Lour. CPC 6980, CPC 6989
Thrixspermum stelidioides Aver. et Averyanova** CPC 7027a
photos
Trichotosia microphylla Blume CPC 7010
Trichotosia pulvinata (Lindl.) Kraenzl. CPC 7001
Vanda sp. CPC 8123a
Zeuxine nervosa (Lindl.) Benth. ex Trimen CPC 8236/8

Orobanchaceae

Aeginetia indica L. CPC 7237, CPC 8239

Passifloraceae

Passiflora foetida L. CPC 7220

Piperaceae

Peperomia sp. CPC 7205

Polygalaceae

Polygala sp.1 CPC 8099

Polygala sp.2 CPC 8110

Polygonaceae

Polygonum sp. CPC 7985

Primulaceae

Lysimachia sp.1 CPC 7236

Lysimachia sp.2 CPC 8222

Ranunculaceae

Anemone sp. CPC 8221

Clematis sp. CPC 8097

Rhamnaceae

Gen.sp. CPC 8060

Rosaceae

Eriobotrya sp. CPC 7934

Photinia cucphuongensis T.H.Nguyen & Yakovlev** CPC 7932
photos

Rubus sp. CPC 7976

Rubiaceae

Argostemma sp.1. CPC 7153

Argostemma sp.2 CPC 7172

Hedyotis sp.1 CPC 6972
Hedyotis sp.2 CPC 7937
Hedyotis sp.3 CPC 8214
Ixora sp. CPC 7108
Lasianthus sp.1 CPC 6968
Lasianthus sp.2 CPC 6976
Lasianthus sp.3 CPC 7922
Lasianthus sp.4 CPC 8119
Lasianthus sp.5 CPC 8135
Mussaenda sp.1 CPC 7009
Mussaenda sp.2 CPC 7160
Mycetia sp.1 CPC 7204
Mycetia sp.2 CPC 7916
Oldenlandia sp.1 CPC 7002
Ophiorrhiza sp.2 CPC 7191
Ophiorrhiza sp.3 CPC 8182
Ophiorrhiza sp.4 CPC 8223
Paederia sp. CPC 8063
Psychotria sp.1 CPC 6966
Psychotria sp.2 CPC 7137
Psychotria sp.3 CPC 7139
Psychotria sp.4 CPC 7212
Psychotria sp.5 CPC 7213
Psychotria sp.6 CPC 8220
Gen.sp. CPC 8039

Rutaceae

Citrus sp. CPC 7018
Clausena sp.1 CPC 7195
Clausena sp.2 CPC 7206
Clausena sp.3 CPC 8100
Evodia sp. CPC 7015
Luvunga sp. CPC 8127
Gen.sp. CPC 7104

Sapindaceae

Gen.sp. CPC 8162

Sapotaceae

Eberhardtia sp. CPC s.n., 7984 ass.

Saxifragaceae

Dichroa febrifuga Lour. CPC 7118

Scrophulariaceae

Scutellaria sp. CPC 8059

Simaroubaceae

Gen.sp. CPC 8102

Smilacaceae

Smilax sp.1 CPC 7013
Smilax sp.2 CPC 7969
Smilax sp.3 CPC 7994
Smilax sp.4 CPC 8204

Solanaceae

Tubocapsicum sp.1 CPC 7054
Tubocapsicum sp.2 CPC 8175
Tubocapsicum sp.3 CPC 8218

Staphylleaceae

Staphyllea sp. CPC 7983

Sterculiaceae

Helicteris sp. CPC 7050
Sloanea sp. CPC s.n., 7984 ass.

Styracaceae

Styrax sp. CPC 7049

Symplocaceae

Symplocos sp. CPC 7048

Theaceae

Camellia sp. CPC 7111
Gordonia sp. CPC s.n., 7984 ass.
Schima wallichii Choisy CPC 8134
Gen.sp. CPC 7029

Thymellaeaceae

Daphne sp. CPC 8229
Wikstroemia sp. CPC 7041

Tiliaceae

Colona sp. CPC 7194
Grevesia sp. CPC 7196
Gen.sp. CPC 8128

Urticaceae

Boemheria sp. CPC 7218
Debregaesia sp. CPC 7229
Elatostema sp.1 CPC 7117
Elatostema sp.2 CPC 7143
Pellionia sp. CPC 7127
Villebrunea sp.1 CPC 7228
Villebrunea sp.2 CPC 7128

Verbenaceae

Callicarpa sp. CPC 7119
Clerodendron sp.1 CPC 8004
Clerodendron sp.2 CPC 8184
Gomphostemma sp. CPC 8038
Gen.sp.1 CPC 7936
Gen.sp.2 CPC 6994

Viscaceae

Viscum articulatum Burm.f. CPC 8069

Vitaceae

Ampelopsis sp.? CPC 7970

Zingiberaceae

Alpinia sp. CPC 6977
Hedychium yunnanense Gagnep.** CPC 7949, CPC 7968 photos
Hedychium sp. CPC 6993
Kaempferia rotunda L. CPC 8181 photos
Zingiber cochleariforme D.Fang CPC 8129
Zingiber guangxiense D.Fang CPC 7951 photos
Zingiber recurvatum S.Q.Tong & Y.M.Xia CPC 8130

Familia unknown

Family1? Gen.sp. CPC 7003
Family2? Gen.sp. CPC 7966
Family3? Gen.sp. CPC 8111
Family4? Gen.sp. CPC 8166

STATISTICS:

Families – 99

Genera – 280

Species – 550

*** 7 species***Calanthe puberula* Lindl.*Cymbidium kanran* Makino*Hoya lyi* H.Lev.*Ophiopogon bockianus* Diels*Phylacium majus* Collett & Hemsl.*Smitinandia helferi* (Hook.f.) Garay*Stereochilus brevirachis* Christenson**** 30 species***Anoectochilus annamensis* Aver.*Bulbophyllum violaceolabellum* Seidenf.*Calanthe alleizettii* Gagnep.*Calocedrus rupestris* Aver. et al.*Collabium chapaensis* (Gagnep.) Seidenf. & Ormerod*Cycas collina* K.D.Hill et al.*Diplopanax vietnamensis* Aver. & T.H.Nguyen*Epigeneium chapaense* Gagnep.*Eria calcarea* V.N.Long & Aver.*Eria pachyphylla* Aver.*Eria thao* Gagnep.*Eriodes barbata* (Lindl.) Rolfe*Habenaria medioflexa* Turrill*Hedychium yunnanense* Gagnep.*Lecanorchis vietnamica* Aver.*Lilium poilanei* Gagnep.*Liparis averyanoviana* Szlach.*Liparis balansae* Gagnep.*Liparis dendrochiloides* Aver.*Liparis pumila* Aver.*Liparis superposita* Ormerod*Lysionotus chingii* Chun ex W.T.Wang*Photinia cucphuongensis* T.H.Nguyen & Yakovlev*Pinus cernua* Aver. et al.***Podochilus oxystophylloides* Ormerod.*Rhomboda petelotii* (Gagnep.) Ormerod*Spatholirion puluongense* Aver.*Thrixspermum stelidioides* Aver. et Averyanova*Trachycarpus geminisectus* Spanner & al.*Trevesia vietnamensis* J.Wen & P.K.Loc***** 12 species***Aspidistra ambigua* sp. nov.*Aspidistra bifolia* Aver., Tillich & K.S.Nguyen, sp. nov.*Aspidistra nutans* Aver. & Tillich*Begonia phaluongense* sp. nov.*Gastrodia khangii* Aver., sp. nov.*Liparis longispica* Aver. et K.S.Nguyen*Ophiopogon alatus* Aver. & N.Tanaka*Oreocharis argyrophylla* W.H.Chen et al.*Oreocharis blepharophylla* W.H.Chen et al.*Peliosanthes kenhilloides* Aver. et N.Tanaka*Phyllagathis pulchella* sp. nov.*Tupistra khangii* Aver. et al.

Schedule and financial report
Brief financial report

Mohamed bin Zayed Species Conservation Fund

Schedule and financial report

Schedule

Time of field survey

21 days, 18 September - 8 October 2016.

Fieldwork locations

Son La province, Moc Chau district (Xuan Nha, Chieng Son, Tan Xuan, Long Sap communes), Yen Chau district (Long Phieng, Phieng Khoai communes).

Team (6 persons)

Project leader: Leonid V. Averyanov.

Participants: Nguyen Tien Hiep, Nguyen Sinh Khang, Chuong Quang Ngan.

Volunteers: Tatiana Maisak, Nguyen Truong Son.

Transportation

2 cars, 2 drivers: Vu Xuan Manh, Nguyen Quang Hieu.

Fieldwork schedule

Day No	Date	Location	Activity description
1	18.09.16	L.Averyanov, T.Maisak	Arrive to Hanoi
2	19.09.16	L.Averyanov, T.Maisak, Hiep, Khang, Ngan, Two driver (Manh, Hieu)	Project team leave Hanoi for Son La Province; prepare logistic for field, stay in Son La City
3	20.09.16	Son La prov.	Processing of permissions for work in Son La.
4	21.09.16	Son La prov., Moc Chau district, Chieng Son commune.	Staff move to Moc Chau district; permission paper work; staff move to Xuan Nha nature reserve, Chieng Son commune.
5	22.09.16	Son La prov., Moc Chau district, Chieng Son	Field survey in Chieng Son commune area
6	23.09.16	Son La prov., Moc Chau district, Chieng Son	Field survey in Chieng Son commune area
7	24.09.16	Son La prov., Moc Chau district, Xuan Nha commune	Field survey in Xuan Nha commune area
8	25.09.16	Son La prov., Moc Chau district, Xuan Nha commune	Field survey in Xuan Nha commune area
9	26.09.16	Son La prov., Moc Chau district, Long Sap commune	Field survey in Long Sap commune area
10	27.09.16	Son La prov., Moc Chau district, Long Sap commune	Field survey in Long Sap commune area
11	28.09.16	Son La prov., Moc Chau district, Tan Xuan commune	Field survey in Tan Xuan commune area
12	29.09.16	Son La prov., Moc Chau district, Tan Xuan commune	Field survey in Tan Xuan commune area
13	30.09.16	Son La prov., Yen Chau district, Long Phieng commune	Staff move to Yen Chau district
14	01.10.16	Son La prov., Yen Chau district, Long Phieng commune	Field survey in Long Phieng commune area
15	02.10.16	Son La prov., Yen Chau district, Long Phieng commune	Field survey in Long Phieng commune area
16	03.10.16	Son La prov., Yen Chau district, Phieng Khoai commune	Field survey in Phieng Khoai commune area
17	04.10.16	Son La prov., Yen Chau district, Phieng Khoai commune	Field survey in Phieng Khoai commune area
18	05.10.16	Son La prov., Yen Chau district, Yen Son commune	Field survey in Yen Son commune area
19	06.10.16	Son La prov., Yen Chau district, Yen Son commune	Field survey in Yen Son commune area
20	07.10.16	Hanoi	Field staff leave Yen Chau for Hanoi
21	08.10.16	Hanoi	Processing of collections
22	09.10.16	Hanoi	L.Averyanov, T.Maisak leave Hanoi

Brief financial report

Project budget USD 12000

2 cars rent during 21 days field work for 4525 km (for cost USD 0.38 per km), $4525 \times 0.38 \times 2 =$ **USD 3440**

Gasoline and oil for 2 cars for 4525 km - **USD 1400**

Road and bridge passing payments **USD 220**

Hiring motorbikes/driver for staff and field equipment transportation in mountain trails **USD 700**

Living cost of the project leader - Prof. L.Averyanov and project participant - T.Maisak in Hanoi 3 nights including Hotel and meal **USD 180**

Accommodation for 8 persons (6 project participants and 2 drivers) during 18 days (1 person, USD 5 per day, $8 \times 18 \times 5$) – **USD 720**

Meal for 8 persons (6 project participants and 2 drivers) during 18 days (1 person, USD 22 per day, $8 \times 18 \times 22$) – **USD 3168**

Field expenses: organizing, permissions processing, phyto-certificate processing for collections export, primary collection processing, payment for National Reserve, hiring of local guides, porters and assistants, field supplies – **USD 1150**

Voucher herbarium specimens processing and shipment, about 2000 specimens – **USD 600**

Field collections analysis, material processing, herbarium label writing and printing, sorting of herbarium specimens – **USD 250**

Post, fax, telephone and miscellations – **USD 200**

Total from Mohamed bin Zayed SCF: USD 12028

Salary of the Project participants for period of field and laboratory works – about USD 10000

Round air tickets of 2 foreign Project participants and baggage transportation – USD 1400

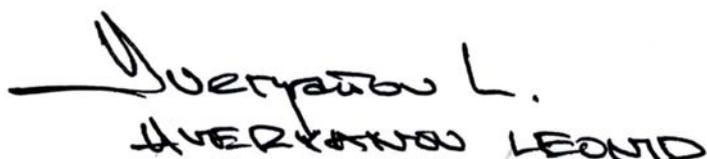
Processing, treatment, sorting, mounting, housing voucher herbarium specimens – USD 600

Fieldwork equipment, including photo cameras, laptops, extra batteries, herbarium paper etc. – USD 800

Total from other sources: USD 12800

Total Project cost: USD 24828

PROJECT LEADER



AVERKYANOV LEONID

Leonid V. Averyanov
5 December 2016