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# The distribution and some ecological characteristics, and essential oil of *Cunninghamia konishii* Hayata in Pu Hoat nature reserve, Nghe An province, Vietnam

Nguyen Thi Thanh Nga*[1)], Nguyen Anh Dung[1)], Nguyen Thanh Chung[2)], Tran Huy Thai[3)] and Nguyen Danh Hung[2)]

[1)]Faculty of Biology, Vinh University, 182 Le Duan, Vinh, Vietnam .
[2)]Pu Hoat Nature Reserve, Nghe An, Vietnam.
[3)]Institute of Ecology and Biological Resources, 18 Hoang Quoc Viet, Ha Noi, Vietnam.

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**Abstract**

In Pu Hoat Nature Reserve, Nghe An Province, Vietnam, Cunninghamia konishii Hayata is normally found on a number of mountainous ranges along part of the border between Lao PDR and Vietnam. They are mainly distributes in 4 communes: Tri Le, Hach Dich, Nam Giai and Thong Thu. This species distributes at altitudinal range from 1,180 – 2,320 m a.s.l and on high slope from $35^0$ - $45^0$, grows in scattered form or becomes concentrated to form the nearly pure population, the average density of population is 8.5 trees / ha with an area of approximately 96.5 ha of natural forest with the reserves totaling 10,448.8 $m^3$. This species is distributed in mixed broadleaf trees - conifer moist evergreen subtropical forest and predominately found in the emergent layer. Regenerated forms of streaks or voids, canopy regeneration of the poor under the forest. Cunninghamia konishii Hayata grows in Ferralic Acrisols (Xha) and Humic Acrisols (Xfa). Twenty-six components have been identified accounting for more than 97.07% of the root oil yield. The major constituents of this oil are α-cedrol (29.18%), β-eudesmol (24.21%), γ-eudesmol (9.34%), thujopsene (6.37%) and α-cedrene (4.28%). β-eudesmol and thujopsene of samples are much more than the samples reported.

**Keywords:** Pu Hoat nature reserve, Vietnam, *Cunninghamia konishii*, Distribution, β-eudesmol

## 1. Introduction

*Cunninghamia konishii* Hayata belongs to Cupressaceae, is found in north and central Taiwan, China (Fujian), north of Laos and Vietnam (Son La, Ha Giang, Thanh Hoa, Nghe An). In Vietnam, its vernacular name is Sa moc dau, Sa mu dau, May lung linh, May lang lenh [1].

*Cunninghamia konishii* has many different values, such as supplying wood, oil and pharmaceuticals. Because the wood of this species is light, aromatic, strong, has commercial value, conifers is over-exploited. The species is threatened at global and national levels, according to the IUCN the species is Endangered (EN)-A2cd; B2ab (ii, iii, v) [2], Near Threatened (VU) - A1a, d, c1 in Vietnam Red Data Book [3]. Although some populations are protected in nature reserves, it is still in danger of extinction. Nghe An Province is the largest distribution of *Cunninghamia konishii* in Vietnam.This species is mainly concentrated along part of the border between Lao PDR and Vietnam which belongs to Western Nghe An Biosphere Reserve. Pu Hoat Nature Reserve, one of three special-use forests in Western Nghe An established in 2013 with the area 85769.53 hectares has many species of animals and plants with many rare genetic sources which needs studying continuously.

In Que Phong district, *Cunninghamia konishii* was first discovered in 1997 [4]. However, conservation of the species in the whole region still lacks information. This study focuses on the distribution, some ecological characteristics and essential oil of *Cunninghamia konishii* Hayata in Pu Hoat NR.

## 2. Materials and methods

### *2.1. Materials*

*Cunninghamia konishii* Hayata in the genus *Cunninghamia*, Cupressaceae, grows naturally in Pu Hoat Nature Reserve, Nghe An Province, Vietnam.

### *2.2. Method*

#### *2.2.1. Data inheritance*

Inheriting selective data sources, documents published related to observed problems.

*Corresponding author.
Email address: nga17tv@gmail.com
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**Table 1** Distribution of *Cunninghamia konishii* Hayata in Pu Hoat NR

| No | Commune | Subregion | Plot | Slope | Height (m) |
|---|---|---|---|---|---|
| 1 | Tri Le | 95 | 10 | $35^0$- $42^0$ | 1335 |
| 2 | Nam Giai | 91 | 5,12,15,16,21 | $40^0$- $42^0$ | 1400 |
| | | 92 | 3,6,7 | $40^0$- $45^0$ | 1650 |
| 3 | Hach Dich | 59 | 1,4,11,15,18,19, 22 | $35^0$- $38^0$ | 1400 |
| | | 60 | 3,4,5 | $40^0$- $42^0$ | 1600 |
| | | 61 | 2 | $40^0$- $45^0$ | 1560 |
| 4 | Thong Thu | 6 | 7,8 | $38^0$- $42^0$ | 1320 |
| | | 46 | 9,10 | $40^0$- $45^0$ | 1200 |

**Table 2** Area and Reserves of *Cunninghamia konishii* in communes

| No | Communes | Reserves ($m^3$) | Area of residence (ha) | Area of distribution (ha) |
|---|---|---|---|---|
| 1 | Tri Le | 258.3 | 12.5 | 70.0 |
| 2 | Hach Dich | 6,703.4 | 43.2 | 712.3 |
| 3 | Nam Giai | 3,234.7 | 35.0 | 1,065.3 |
| 4 | Thong Thu | 252.4 | 5.8 | 323.6 |
| Total | | 10,448.8 | 96.5 | 2,171.2 |

**Table 3** Physical and chemical characteristics of Humic Acrisols at the distribution point of *Cunninghamiia konihii*

| No | Analysis indicator | | Units | Soil layers | |
|---|---|---|---|---|---|
| | | | | 0-30cm | 30-90cm |
| 1 | $pH_{KCl}$ | | | 5.34 | 5.22 |
| 2 | OM | | % | 7.91 | 5.64 |
| 3 | $N_{total}$ | | % | 0.27 | 0.20 |
| 4 | Nabsorbed | | mg N/100g | 19.1 | 17.2 |
| 5 | $P_2O_{5total}$ | | % | 0.11 | 0.11 |
| 6 | $P_2O_5$absorbed | | mgP2O5/100g | 15.3 | 13.8 |
| 7 | $K_2O_{total}$ | | % | 0.89 | 0.97 |
| 8 | $K_2O$ absorbed | | mg K2O/100g | 14.13 | 13.7 |
| 9 | CEC | | meq/100g | 18.76 | 14.43 |
| 10 | Exchange acidity | | meq/100g | 2.13 | 2.05 |
| 11 | Hydrolytic acidity | | meq/100g | 6.76 | 6.02 |
| 12 | Humidity | | % | 1.55 | 1.68 |
| 13 | Bead-level | 2-0,02 | % | 26.14 | 28.66 |
| | component (%) | 0,02-0,002 | % | 47.02 | 46.02 |
| | | <0,002mm | % | 28.64 | 25.28 |

*2.2.2. Fieldwork*

Carrying out surveys and interviews with national park rangers and local people involved to gather information about the survey location and distribution by method of detection - PRA. On the basis of survey results, interviewing to identify regional - scale distribution of *Cunninghamia konishii* in Pu Hoat NR and carrying out route survey: we carried out the establishing route survey, using the method of delineating the survey route and the method of delineating the opposite slope to draw species distribution area, on the main survey route, we open survey subroute, and setting up standard subplots 20m x 25m (area of 500$m^2$). We set the number of standard subplots depending on the species distribution area [5]. We identified the location, population distribution by GPS and collected biological data of the species such as geographic coordinates, height above sea level (m), slope, terrain and characteristics of the soil, tree height- Hdc (m), diameter D1.3-DBH (cm), forest composition, regeneration situation.

*2.2.3. Analysis of essential oil*

Root of *Cunninghamia konishii* was collected in June 2015 in Pu Hoat Nature Reserve, Nghe An Province, Vietnam (Nam Giai, elevation 1,385m, N 19º44´30″, E 104º45´21″). Root of *Cunninghamia konishii* (1Kg) was hydro distilled for 8 h with 3 L of distilled water. The amount and composition of the essential oils was determined by gas chromatography-mass spectrometry (GC/MS) using a Hewlett-Packard HP 6890 with Mass Selective Detector Agilent 5973. HP-5MS column (30 m x 250 µm x 0.25 µm film thickness) and HP-1 (0.25 mm x 30 m x 0.32 mm). Oven temperature was programmed as follows: 60ºC for 2 min, rising to 220ºC at 4ºC/min. Injector temperature: 260ºC. Carrier gas: He. The components were identified by comparison of their mass spectra with NIST 1998 library data with the relevant literature data [6-8].

*2.2.4. Data processing*

The Density Calculator uses the formula N/ha= $\frac{n}{So}$ x 10.000 (trees/ha); **N** is the number of trees in one hectare; **n**: Number of trees in a standard subplot; **So**: Area of standard subplot ($m^2$). The mixing degree with other trees of the formula: $\mathbf{P_i}\% = \frac{ni}{N}$ x 100; $P_i$%: Percent of **i** species in the total standard subplots; $\mathbf{n_i}$ : Number of occurrences of **i** species in the total standard subplots; N: Total standard subplots [9]. Forest reserves are calculated using the formula: M= ΣG x H x f1.3 ($m^3$); **Σ G** : Total basal area of a forest stand, **H**:

Average height of the trees, **f 1.3**: Figure 1.3 [5]. Regional distributions of species are plotted using MapInfo.

*2.2.5. Analysis of soil*

The soil sample was analyzed at the Laboratory in Institute of Regional Research and Development, Ministry of Science and Technology according to current standards of Vietnam (TCVN) [10].

## 3. Results

*3.1. Distribution characteristics*

The fieldwork survey has identified that in Pu Hoat Nature Reserve *Cungninghamia konishii* Hayata only distributed on some mountainous ranges which belong to communes: Tri Le, Hach Dich, Nam Giai and Thong Thu (Table 1).

*3.2. Ecological characteristics*

*Cunninghamia konishii* scatters in clusters of 3-5 trees or concentrates nearly pure populations, creating populations from 27- 222 trees, the trees in these populations are from 0.2 m to 3.7 m in diameter at breast height and the height is 8 m to 60 m. The average density of the population is 8.5 trees/ha, the area of residence of the species 96.5 ha with total reserves of approximately 10,448.8 $m^3$ (Table 2).

*Cunninghamia konishii* mixed with 62 species of vascular plants which belong to 27 families recorded. The survey shows that it's rare to see seedlings around the mother trees, *Cunninghamia konishii* seedlings only grow more in landslides along the slopes of ridges and empty land beside ravines in Pu Hoat NR. This species grows on Ferralic Acrisols- (Xfa) and Humic Acrisols-(Xha). Analysis of sample Humic Acrisols has shown that clay beads at the soil layer 0cm - 30 cm is 28.64%, the soil layer 30cm - 90cm is 25.28%, soil acidity pH = 5.22 to 5.34. Humus in the soil layer 0cm - 30cm is 5.64%, the soil layer 30cm - 90cm is 7.91%. The total number of N, P, K in the soil is 0.27%; 0.11%; 0.89%, $NH4^+$, $K_2O$, $P_2O_5$ easily absorbed is 17.2%; 13.8%; 13.7% (Table 3).

*3.3. Root of essential oil*

The root of *Cunninghamia konishii* Hayata were collected from Que Phong district, Nghe An province.Twenty - six components have been identified accounting for more than 97.07% of the oil yield. The major constituents of this oil are α-cedrol (29.18%), β-eudesmol (24.21%), γ-eudesmol (9.34%), Thujopsene (6.37%) và α-cedrene (4.28%). The other component is less than α-calacorene (3.32%), δ-cadinene (3.02%), γ-muurolene (2.05%), elemol (1.78%), levomenol (1.64%), α-curcumene (1.46%), cuparene (1.39%), dehydro aromadendrene (1.16%), agarospirol (1.12%). The remaining contained by weight from 0.17% to 0.99% are valerenol, β-selinene, $\delta^3$-carene, zingiberene, Diepi-α-cedrene, Cyclohexasiloxane, dodecamethyl-, alloocimene, manool, Trans-α-fanesene, 2,6-dimethyl-2,4,6-octatriene, α-chamigrene và β-himachalene.

## 4. Discussion

Results of fieldwork has identified that *Cunninghamia konishii* usually distributed on a number of mountainous ranges along part of the border between Lao PDR and Vietnam with fragmented habitats, were growing at headwater of ravines along watersheds between slots and halfway up the mountains and did not grow at the top of mountains, elevations of 1,180m – 2,320 m, slopes ranged from $35^0$- $45^0$ in communes: Tri Le, Hach Dich, Nam Giai and Thong Thu in Pu Hoat NR (Figure1).

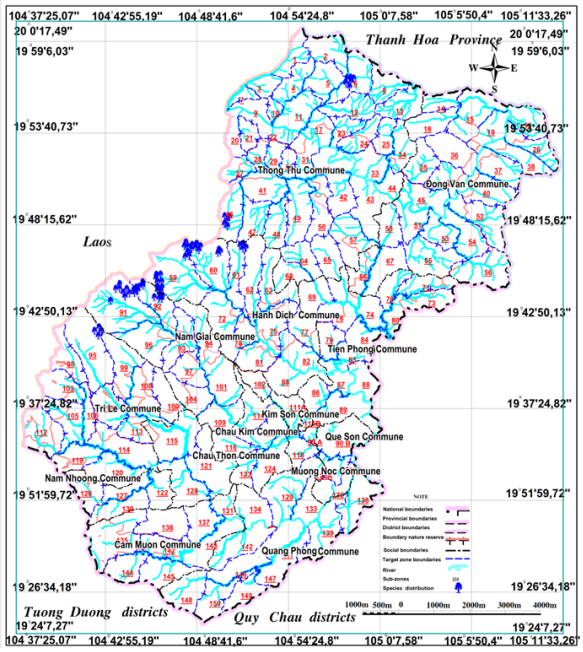


**Figure 1** Distribution of *Cunninghamia konishii* Hayata in Pu Hoat NR

*Cunninghamia konishii* scatters in clusters or concentrates to form nearly pure populations because of regenerative characteristics of the species under regenerative forms of streaks or voids. Reproductive characteristics of the species: ripe seeds are difficult to unfix out of cones and when cones fall into thick litter layer, seeds germinate on cones. However, seedings rarely touch the ground. Developing seedlings need light.

In the study regions there is a population of 222 trees. This is the largest population of *Cunninghamia konishii* which has been known in Vietnam up to now (N $19^0$47'05'' E$104^0$ 47'56''). The majority of the individuals in the population are maturity reproducted, the trees with over 1m diameter usually start to hollow gradually. The largest tree of Pu Hoat Nature Reserve is located in the plot 4, subregion 60 in Hach Dich communes (N$19^0$ 44' 22'' E $104^0$ 46' 15'') has a diameter of 3.7 meters and is 55m in height. The area of residence of the species occupies a much smaller proportion ( 96.5 ha**)** than the total area of distribution (2,171.2 ha), the largest reserve of wood is in Hach Dich (6,703.4 $m^3$) and the smallest reserve of wood is in Thong Thu (252.4 $m^3$).

*Cunninghamia konishii* often grows with some species of *Symingtonia populnea* (R. Br. ex Griff.) (Hamamelidaceae), *Carallia suffruticosa* Ridl. (Rhizophoraceae), *Engelhardtia roxburghiana* Wall (Juglandaceae), *Guarea excelsa* Kunth (Meliaceae), *Castanopsis ferox* (Rosb.)(Fagaceae), *Michelia mediocris* Dandy (Magnoliaceae), *Pellionia radicans var. grande* (Gagnep.) H. Schroter (Urticaceace), *Ardisia quinquegona* Blume (Primulaceae), *Litsea acutivena* Hayata (Lauraceae), *Litsea yunnanensis* Y. C. Yang & P. H. Huang (Lauraceae), *Alniphyllum fortunei* (Hemsley) Makino

(Styracaceae). Associated conifer species include *Fokienia hodginsii* (Dunn) Henry et Thomas, *Dacrycarpus imbricatus* (Blume.) de Laub, *Nageia fleuryi* (Hiekel) de Laub. and *Podocarpus neriifolius* D. Don. This species is predominantly found in the emergent layer and it is the light demanding species

*Cunninghamia konishii* grows in Humic Acrisols which has average mechanical composition, porosity, average soil absorption capacity (CEC), high humus content (OM), less acidic. Total N in the fair, passable level of P, K total wealth levels; $NH_4^+$ easily digested, easily digestible $P_2O_5$ at very rich. $K_2O$ inadequate digestion [11].

The Comparison of the main component of root oil sample of *Cunninghamia konishii* in Pu Hoat Nature Reserve, Nghe An Province in the present work with those reported in the literature suggested some comments:

- Cedrol (29.18%) is similar to those in the samples in Vietnam (11.2% - 37.0%) [12-14] and less than the samples in Taiwan (53% -58.3%) [15-16].

- β-eudesmol (24.21%) of the sample is more than that of the sample in Thanh Hoa Province (3%) [16], the other samples don't contain it.

- γ-eudesmol (9.34%) is similar to the sample in Thanh Hoa Province (8.8%) [13] and samples of other regions don't contain it.

- Thujopsene (6.37%) of the sample is considerably higher than the sample in Ha Giang Province (0.6%) [13], other samples don't contain it.

- α-cedrene (4.28%), this compound is presented in all the samples (3.4% - 18.4%).

## 5. Conclusion

*Cunninghamia konishii* Hayata in Pu Hoat Nature Reserve, Nghe An Province, Vietnam, is normally found on a number of mountainous ranges along parts of the border between Lao PDR and Vietnam. This species is distributed at altitudinal range from 1,180m – 2,320 m a.s.l, at high slope from $35^0$- $45^0$and grows at the foothills and the mountainside in 4 communes: Tri Le, Hach Dich, Nam Giai and Thong Thu. They grow scattering 3-5 tree or constitutes to form the nearly pure population, the average density of the population is 8.5 trees/ ha with an area of approximately 96.5 ha of natural forest with total reserves of 10,448.8 $m^3$.

This species associated conifer species include *Fokienia hodginsii* (Dunn) Henry et Thomas, *Dacrycarpus imbricatus* (Blume.) de Laub, *Nageia fleuryi* Hiekel) de Laub. and *Podocarpus neriifolius* D. Don *Cunninghamia konishii* usually occurs in mixed with some species of families Lauraceae, Fagaceae, Magnoliaceae, Elaeocarpaceae, Primulaceae, Meliaceae, Hamamelidaceae, constituting the main canopy of mixed broadleaf trees-conifer moist evergreen subtropical. Regenerated forms of streaks or voids, regeneration capacity of the species under the forest canopy is low. It grows in Ferralic Acrisols - Xfa and Humic Acrisols - Xha. Humic Acrisols has rich nutrition, loose soil and is less acidic.

Essential oil was isolated by steam distillation and analyzed by Capillary GC/MS. Twenty-six components have been identified accounting more than 97.07% of the root oil yield. The major constituents of this oil are α-cedrol (29.18%), β-eudesmol (24.21%), γ-eudesmol (9.34%), thujopsene (6.37%) and α-cedrene (4.28%). β-eudesmol and thujopsene of samples are much more than the reported samples.

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