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The phytogeographic note on the orchids flora of Vietnam: a case study from the Hon Ba Nature Reserve, Central Vietnam

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ABSTRACT: The survey of the Orchid flora at Hon Ba Nature Reserve, where was a part of the famous Annamite Range in Vietnam, had been achieved from March to December 2014. A total of 106 species in 4 life forms were accounted i.e. epiphyte (67 species), terrestrial (20 species), lithophyte (13 species) and mycoheterotrophic (6 species). Among those, there were two newly recorded species to the Annamite Range i.e. *Lecanorchis nigricans* Honda and *Bulbophyllum dasystachys* J.J.Verm., P. Thavipoke & J. Phelps. The most diverse genera were *Dendrobium*, *Bulbophyllum*, *Liparis* and *Paphiopedilum* respectively. The result area revealed that the Annamite Range performed as a "cross road" of 4 floristic regions in Asia, i.e. the Himalayan Range, the Indo-China Mainland and Myanmar, the Sino-Japanese and the Malesian Region.

KEY WORDS: Annamite Range, Biodiversity, Orchidaceae, Phytogeography, Vietnam.

INTRODUCTION

Vietnam is one of the famous regions for the high diversity of orchids due to the fact that the country is situated in the concurrence area concerning phyto-geographical distribution. It is no doubt that the area along this Annam cordillera which arose in the North of Vietnam, down to Me Kong delta in the South is the area where high diversity of orchids of the world could be expected. Less botanical surveys as well as less plants collections in the past due to the political instabilities in Vietnam, has led to the underestimation of the number of orchid species in this area. More account on the diversity of orchids of the area mentioned, might support the comprehensive understanding of the phyto-geographical patterns, not only for the orchid flora, but also other plant species of the Indochinese region in general. The information on the Orchids of Vietnam have been gathered and documented by many botanists so far as follows: Gagnepain and Guillaumin (1934); Pham (1972, 1993, 2000); Averyanov (1990, 1994, 1996, 1997, 1999, 2005, 2008, 2010, 2011); Seidenfaden (1992); Tran (1998); Nguyen (2001). On the Update checklist of Orchid of Vietnam in 2003, Leonid Averyanov has documented 897 species in 152 genera. Orchid of Vietnam has the wide range of distribution from Himalayas, South East Asia and Malesian. There around 19.2% of orchid are endemic to Vietnam. Averyanov *et al.* (2003).

Hon Ba Nature Reserve

Mountainous Hon Ba Nature Reserve is located within the Da Lat plateau in the Annamite range. The vegetation is belonging to lower montane forest type according to the classification in Whitemore (1980). Considering bio-geography, it belongs to an Indo-china province in South Annamite floristic region according to Averyanov *et al.* (2003). It was selected as a study site for evaluating orchid diversity according to its good location in this well-known Annamite range as well as its well preserved natural forest with less anthropogenic disturbance and its rich flora which contained many endangered species e.g. *Pinus krempii* Lecomte; *Fokienia hodginsii* (Dunn) A. Henry & H.H. Thomas; *Aquilaria crassna* Pierre ex Lecomte; *Rhodoleia championii* Hook. f.; *Paphiopedilum delenatii* Guillaumin; *P. appletonianum* (Gower) Rolfe etc. Primarily, the present work is trying to document the orchid diversity of this famous phyto-geographical region of the Annam cordillera by using the Hon Ba Nature Reserve as a case study site.

MATERIALS AND METHODS

Study Area

Hon Ba nature reserve located on the South Annamite range near the South China sea coastline (latitude ca.12°01′45″–12°12′00″N and longitude ca. 102°53′45″–109°02′34″E) with a total area of about 19,164 hectares. The altitude is ranging between 50–1,578 m asl. with the average slopes around 15°–40° (Fig. 1). Structurally, It is composed of mostly granite rocks and built up by cretaceous plutonic rocks (granite, granodiorite, leucocratic granite). An exposures of contact metamorphosed Jurassic sedimentary rocks occurred at the base of the mountain mass if at the North West and South West borders (siltstones, clay stones, shales and sandstones,

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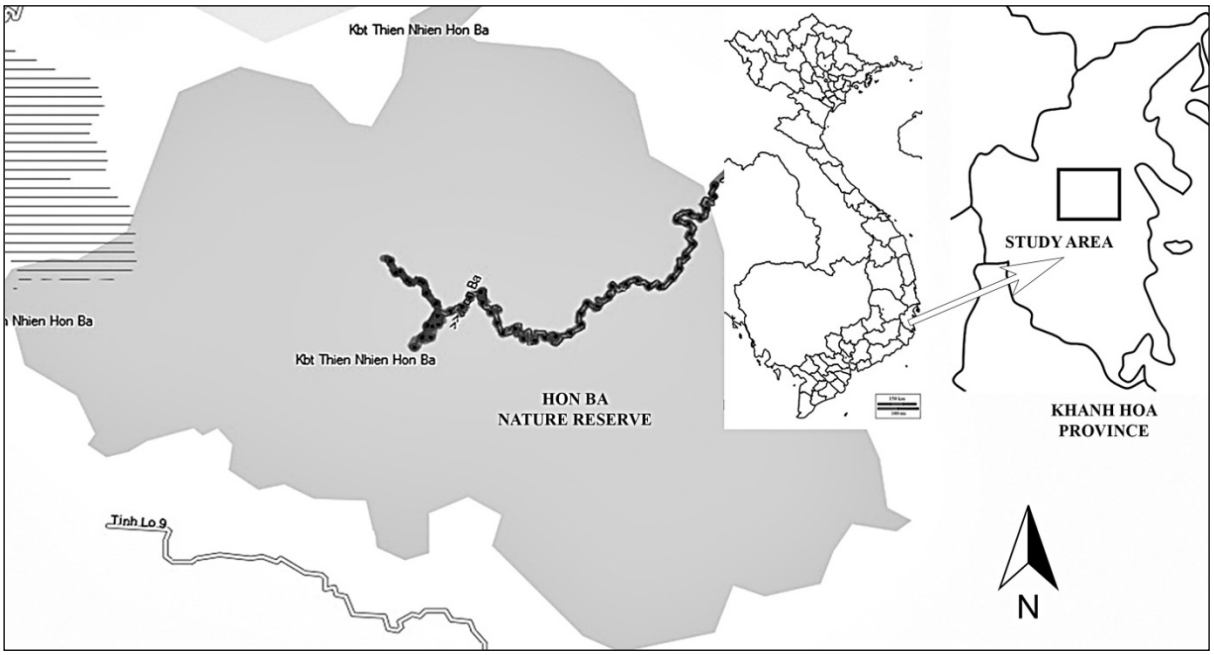


Fig. 1. Map of study side Hon Ba nature reserve.

metamorphosed to spotted and knotted schists and hornfels) (Technical report of Hon Ba nature reserve, 2013).

The climate of Hon Ba is monsoon tropical climate (Am) according to Köppen's climate classification system (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006). The raining occurred almost every day; no dry month exists. In addition, heavy rains of 2,500–3,851 mm could also take place. The number of rainy days/month is >20 (Schmid, 1974). In general, the rainfall in Hon Ba would start in November, and it rains regularly in this month of ca. 678 mm (Fig. 2). The mean temperature in the area in the warmer months is around 18.6–19.8°C, while in the cooler time is ca. 14.7–16.9°C. The mean humidity all year round is always > 90% which could reach to 98% occasionally. (Technical report of Hon Ba nature reserve, 2013)

Due to the location of the study area which had fallen into the concurrence of different phyto-geographic regions as well as the regular rainfall in such high altitude mountain (> 1,200 m) with the connection to the oceanic climate that might support the growth of rather wild range of orchids, therefore various orchid elements from different phyto-geographic regions could be expected.

Data collection

The orchid collection was carried out once a month from March 2014 to December 2014 in order to cover all flowering seasons of the orchids. All had been made with photographs of their habitats as well as available field notes. Selected collecting trails had covered different altitudinal areas from ca. 200 m asl. to the summit at ca. 1,578 m. Moreover, the trials had covered various types of micro-habitat in various (non/less

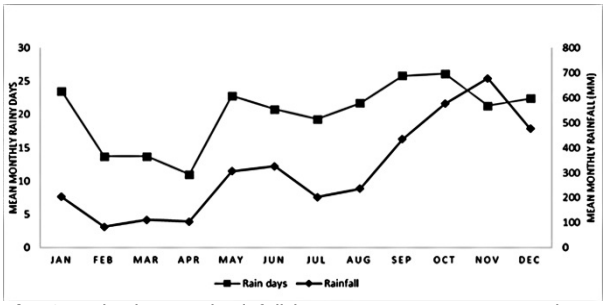


Fig. 2. Rain days and rainfall in Hon Ba nature reserve. (Data source: Technical report of Hon Ba nature reserve)

disturbed) vegetation types where orchids occurred e.g. terrestrial on soil; rocky areas; shady habitats; open-sunny habitats; along stream; epiphyte on trees etc. The specimens had been processed as dry and/or spirit according to Forman and Bridson (1999).

Laboratory work

Orchid specimen collected were identified according to available taxonomic references (Averyanov, 1999, 2005, 2008, 2010, 2011; Averyanov & Averyanova, 2003; H. A. Pedersen, 2011; H. Æ. Pedersen *et al.*, 2014; Schuiteman & De Vogel, 2000; Seidenfaden, 1992; Seidenfaden & Wood, 1992) The line drawings would be made from some selected interesting taxa. The distribution pattern of each taxon had been assumed by comparing with herbarium specimens in Thailand (BCU, BK, BKF and PSU) and in Vietnam (VNM) as well as the distributional data from available taxonomic literature concerning the orchids in this region of the oriental Asia. Voucher specimens were deposited at Vietnam national herbarium (VNM).

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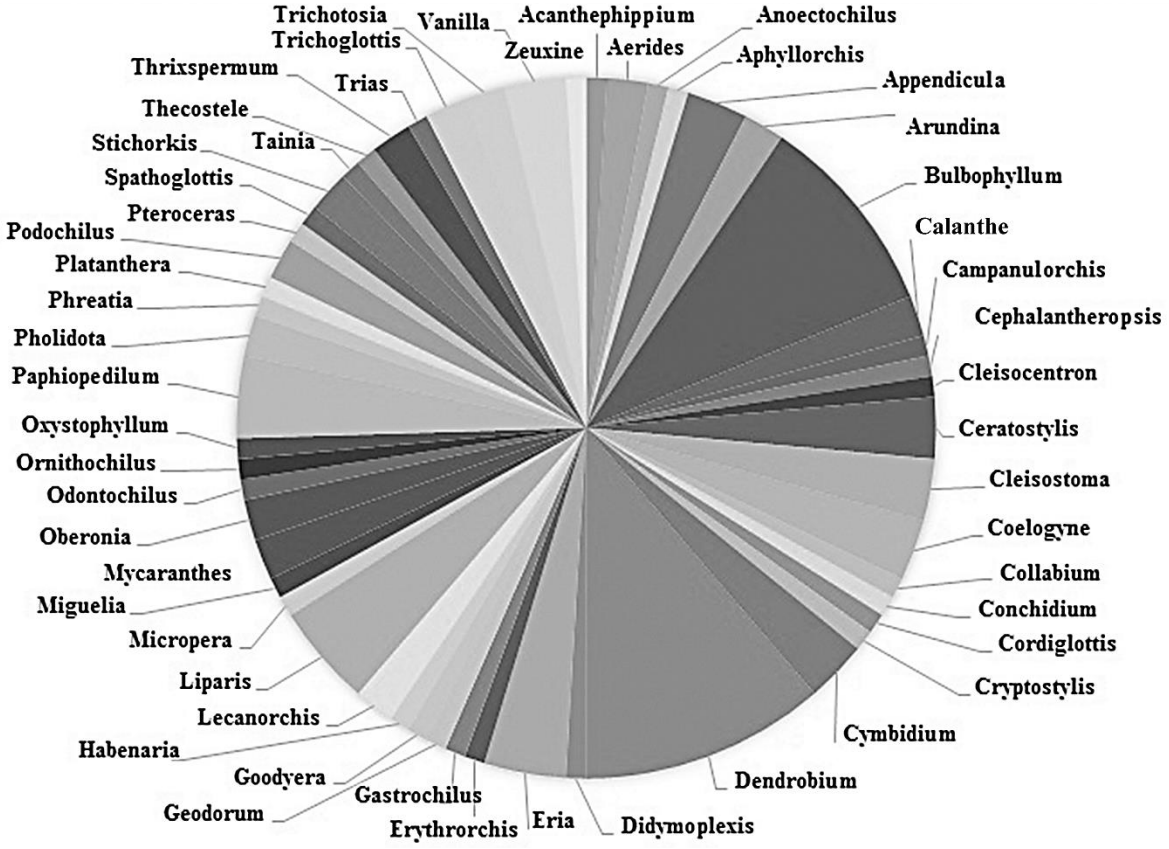


Fig. 3. Proportion of different genera of Orchids found in Hon Ba nature reserve.

Phytogeographic notes making procedure

Each identified orchid species would be compared with the distribution information in the available orchid literature of the regions mentioned in the results in order to achieve the phytogeographic notes.

The phytogeographic regions applied here are according to Good (1964) which modified and used by Takhtajan (1969); Van Steenis (1948, 1950) and Whitmore (1984) i.e. the Himalayan (mountain) range; the Sino-Japanese; the Indo-China; the Mainland South-east Asia and the Malesian region.

RESULTS

The Species Richness.

A total of 106 species of orchids belonging to 52 genera were recorded. Among them, the genera *Dendrobium*, *Bulbophyllum*, *Liparis*, *Paphiopedilum* were the most diverse orchids. (Figs. 3, 4; Appendix 1)

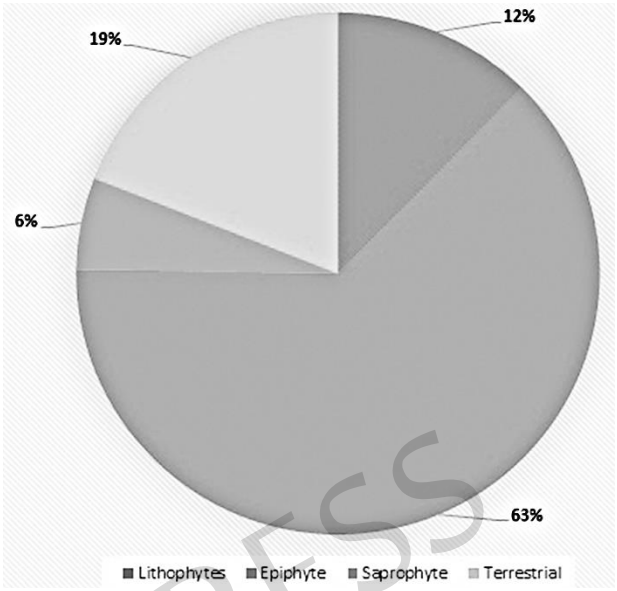


Fig. 4. Number of species by life form.

The orchid diversity at Hon Ba Nature Reserve along altitudinal gradient.

The numbers of the orchid species found at Hon Ba Nature Reserve had reached its peak at the altitudinal range between 1,200–1,500 m (Fig. 5). And this falls into the areas of lower montane forest vegetation where rather moist condition of habitats with more/less "cool" temperature were found. This is also quite characteristic among other types of vegetation in the Tropic. Moreover, various kinds of micro habitats due to the dense canopy

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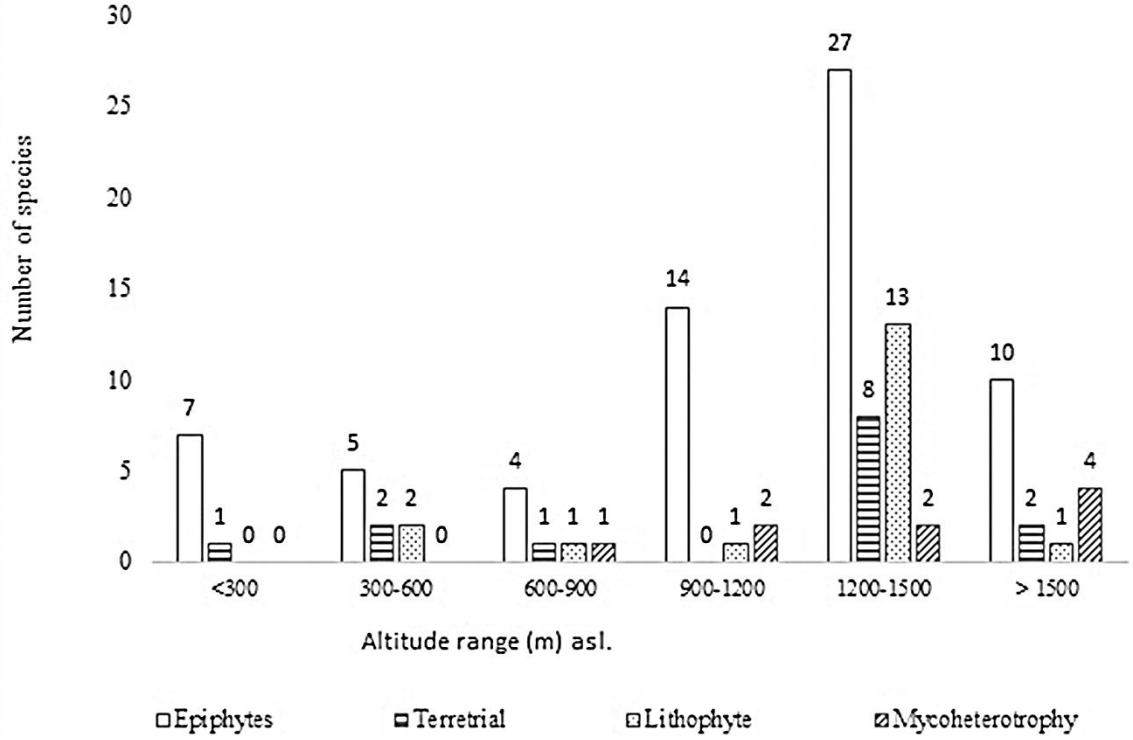


Fig. 5. Distribution of Orchid species by altitude at Hon Ba Nature reserve.

vegetation as well as the topographic features of the areas e.g. close trees and shady tree; open sunny canopy on the top V.S. close canopy at the bottom; rocky; rich humus soil with always humid condition etc., might accommodate various life form of orchids. And when life forms of the orchids in the areas were taken into account, it is no doubt to see that the epiphytic orchids were the most diverse group among all other life form groups and the mycoheterotrophic orchids, that have been considered as rare orchids in general, were the least diverse ones. However, it is to be noticed here that the lithophytic orchids had reached their most diverse in such high altitude over 1,200–1,500 m (Fig. 5), though rocky condition could be normal for all over the areas from the low altitude to the high one. This is due to the fact that the lower montane forest in such higher altitude contains high humidity, moreover, it produced much litter/humus that, later, deposited on the rock surface as well as the bark of the trees. This would be favored by many orchid species comparing to the rocky areas in other vegetation types with lower humidity and less litter. Common species of orchids between epiphytic and lithophytic ones in such high altitude could be recognized e.g. *Campanulorchis globifera* (Rolfe) Brieger; *Pholidota chinensis* Lindl.; *Appendicula hexandra* (J. Koenig) J.J. Sm.; *Appendicula reflexa* Blume; *Coelogyne mooreana* Rolfe. etc.

The distribution patterns of orchids by floristic regions.

Considering the orchid species found in the study area, five patterns of the distribution ranges of the orchid elements found could be recognized. (Appendix 1)

The Himalayan range elements (Fig.6): Orchid species confined to this distribution range occurred only in the mountainous areas over 1,000 m asl., mostly with special conditions of a habitat (moist; cool; littered etc.) and therefore, considered as rare orchids e.g. *Bulbophyllum delitescens* Hance; *Dendrobium aduncum* Lindl.; *D. amplum* Lindl.; *Eria globulifera* Seidenf.; *Oberonia longibracteata* Lindl.; *Trias nasuta* (Rchb.f.) Stapf.

The Indo-china (including Myanmar) elements (Fig.6): Species fall into this distribution range could be found both on the highland areas e.g. mountain; plateau or in the lowland areas e.g. Campanulorchis globulifera (Rolfe) Brieger; Ceratostylis siamensis Rolfe ex Downie etc. and one new record species orchid of Vietnam i.e. Bulbophyllum dasystachys J.J.Verm., Thavipoke & J. Phelps which had been discovered as a second record so far in the present study since it was first described (type from unknown source in Thailand?), had confirmed the characteristic of this range of distribution that contain many species confined to only this Indo-China Mainland.

The Malesian region elements (Fig.6): The example of orchids of the Malesian region; Peninsular Thailand and some occurred also in South-eastern part of Thailand next to Cambodia as well as in Cambodia which had been found in Hon Ba Nature Reserve are: *Aphyllorchis pallida*

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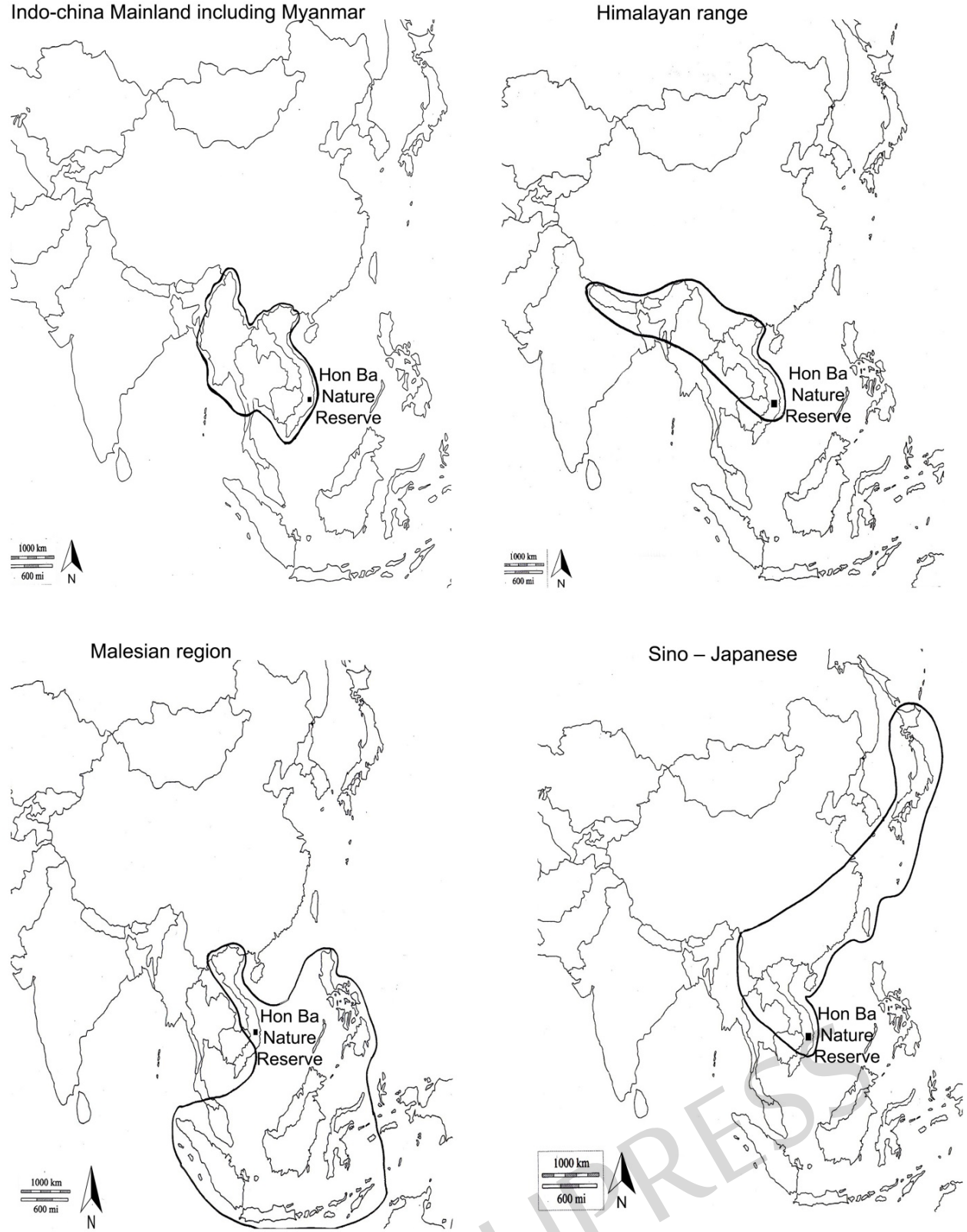


Fig. 6. Distribution ranges of the orchid species found in Hon Ba Nature Reserve, Central Vietnam in different floristic regions of South-East & East Asia.

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Blume; *Appendicula hexandra* (J. Koenig) J.J.Sm.; *Phreatia densiflora* Lindl.; *Trichoglottis retusa* Blume and *Vanilla albida* Blume. In addition, *Stichorkis compressa* (Blume) J.J.Wood is the only Malesian element found in this Annamite Range at Hon Ba Nature Reserve which has different route of distribution to other Malesian elements found, as this one had been recorded only in the Philippines archipelago and west Borneo, then Vietnam and not even on the mainland Malesian in the Peninsular Malaysia.

The Sino – Japanese elements (Fig.6): Few species of orchids had been found confining only to the oriental part of Asia in Japan and South-East China down to the North of Thailand and Laos. One was *Zeuxine agyokuana* Fukuy. And the other is the new record species to Vietnam i.e. *Lecanorhis nigricans* Honda, discovered as first time in the Annamite Range in the present study.

The endemic elements to the Annamite range: There are quite numbers of the orchid species that characterized the floristic region of this Annamite range in particular, which have never been recorded anywhere else. Some could be seen at Hon Ba Nature Reserve i.e. *Bulbophyllum delitescens* Hance; *B. frostii* Summer. *Cleisocentron klossii* (Ridl.) Garay; *Trichoglottis seidenfadenii* Aver.

There are few orchid species which have wide range of distribution in various floristic regions. They may occur mostly in such disturbed habitats or on the edge of the forest i.e. *Arundina graminifolia* subsp. *graminifolia* (D.Don) Hochr.; *Bulbophyllum apodum* Hook.f.; *Cleisostoma williamsonii* (Rchb.f.) Garay; *Coelogyne fimbriata* Lindl.; *Cryptostylis arachnites* Blume.; *Dendrobium spatella* Rchb.f.; *Spathoglottis plicata* Blume; *Thrixspermum centipeda* Lour.; *Liparis caespitosa* Lindl. *Mycaranthes floribunda* (D.Don) S.C.Chen & J.J.Wood; M. Pannea (Lindl.) S.C.Chen & J.J.Wood. And some have lager distribution range, extended to Japan or vice versa i.e. *Calanthe angustifolia* Lindl.; *C. lyroglossa* Rchb.f.; *Cymbidium dayanum* Rchb.f.; *C. lancifolium* Hook.; *Erythrorchis altissima* Blume.

Two newly recorded species to the Annamite range of Vietnam.

Lecanorchis nigricans Honda, Bot. Mag**.** (Tokyo) 45: 470. 1931; J. Ohwi, Fl. Japan (in English): 336. 1965; T. S. Liu & H. J. Su, Fl. Taiwan 5: 1039. 1978; T. Hashim., Ann. Tsukuba Bot. Gard.9: 27. 1990; X. Chen *et al.*, Fl. China 25: 172. 2009. S. Suddee *et al.*, Thai Forest Bull., Bot. 38: 2–4. 2010. H. Æ. Pedersen *et al.*, Fl. Thailand 12(1): 178. 2011. (Fig. 7)

Terrestrial, mycoheterotrophic, rhizomatous herbs; rhizome dark brown, slender, curved in hooked-like, forming aerial flowering shoot, branched. ***Flowering shoot*** 6–17 cm long erect, dark brown; nodes with sheaths; sheaths glabrous, ovate, ca. 0.3 cm long, apex acute, base amplexicaul, margin membranous. ***Inflorescence*** in raceme, glabrous; rachis ca. 2.5–10 cm long, 3–16 - flowered; bracts ovate, glabrous, brown, apex acute, 0.2–0.25×0.1–0.2 cm. *Flowers* long – pedicelled, yellowish. ***Dorsal sepal*** yellowish - green, glabrous, oblanceolate with 3–5 -veined, mid vein rather dark brown, apex obtuse 1.3–1.35×0.2 cm, concave. ***Lateral sepals*** yellowish green, glabrous, oblanceolate, mid vein dark brown, apex obtuse, 1.35–1.4×0.2–0.25 cm, concave, flattened. ***Petals*** yellowish-white, glabrous, oblanceolate, apex obtuse, ca. 0.45–0.5 cm×0.15–0.2 cm, concave, flattened. ***Labellum*** purplish-white, simple, spathulate-obovate, 6–7-veined, ca. 1.3–1.4×0.5–0.7 cm, flattened, adnate to column for more or less half of the column length then forming a tube with basal papillose inside; epichile purplish, slightly 3 lobed with obscure side lobes or not lobed, mid lobe/limb obtuse, slightly expanded with incurved irregular margin, pubescent with multicellular hairs. ***Column*** white, glabrous, incurved, 1.2 cm long, winged at the top end; anther white, glabrous, 0.02 cm long. ***Ovary*** *(plus pedicel)* glabrous, ca. 1.5–2cm long. ***Capsule*** fusiform, 2.5×0.5 cm.

Distribution: Japan (type locality), South China, Taiwan, Thailand and Vietnam

Ecology: Primary humid broad–leaved evergreen montane forests, ca. 966 m asl. Flowering time July.

Note: The specimen collected from the Hon Ba Nature reserve performed characters as an intermediate form between two close related taxa i.e. *Lecanorchis nigricans* and *L. amethystea* Y. Sawa, H. Funaga & S. Sawa whose type localities were both in Japan. Therefore, it is possible that both names proposed might belong to the same taxon. In any case, it is hesitated to make such decision here in the present study as more information on the specimens investigations as well as population study of both species from the regions where they occurred need to be taken into account. In addition, *L. nigricans* was also recorded recently as the first time in South-eastern and Central Thailand (S. Suddee, S. Chantanaorrapint, P. Tripetch and S. Thainukul, 2010) that was in the region next to the Indo-China region where Vietnam belongs to. Then it is reasonable to suppose that the distribution range of *L. nigricans* might also expand naturally to the neighboring area in Vietnam rather than *L. amethystea* which was known only from the type locality. Moreover, according to the original publication of the latter (Y. Sawa, H. Fukunaga, and S. Sawa, 2006), the characteristic features both vegetative as well as reproductive were so close to the former that they differ from each other mostly by sizes when characters were taken into account one by one for considering. More specimens and various localities of collections would be, therefore, needed in order to clarify the status of, especially, *L. amethystea*.

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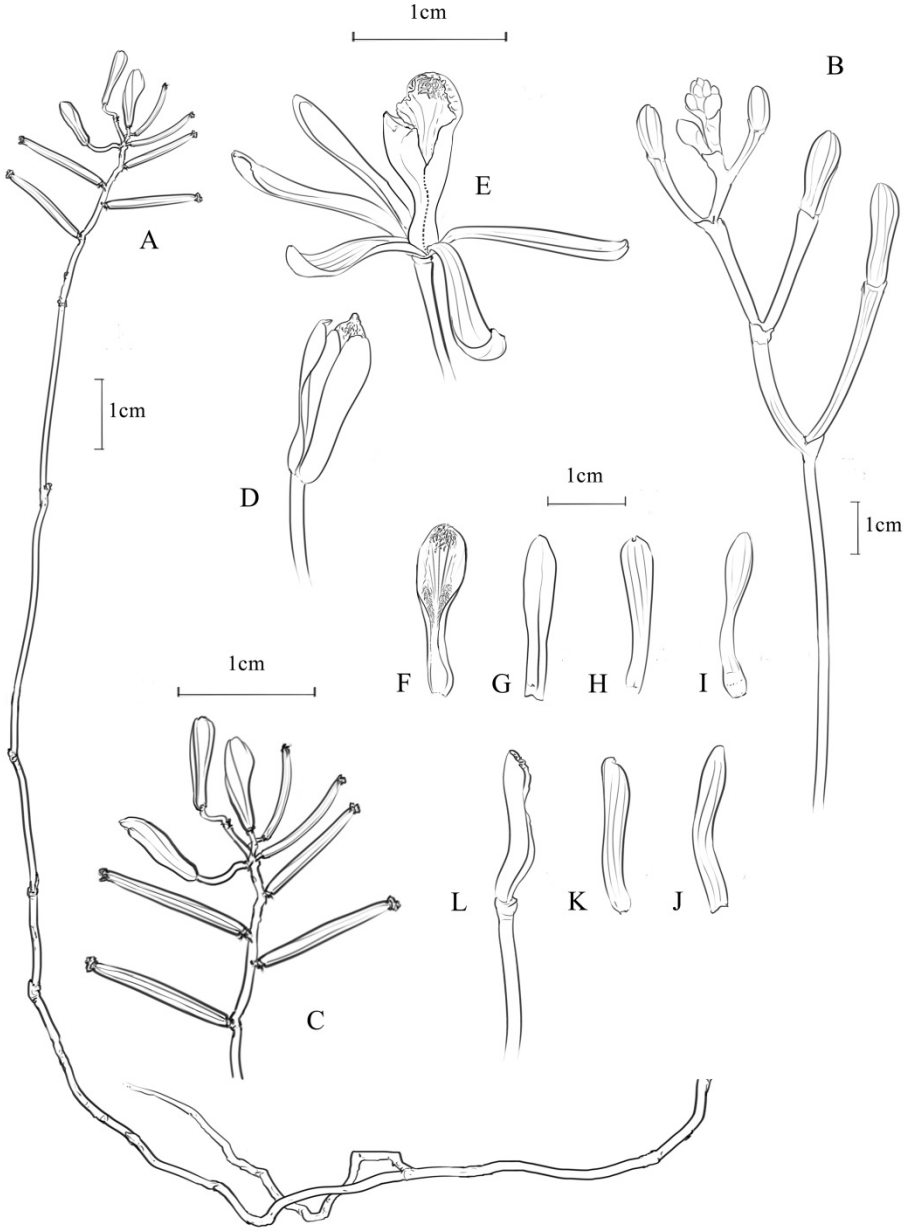


Fig. 7. Illustration of ***Lecanorchis nigricans*** Honda. **A**: Habit. **B**: Inflorescence. **C**: Inflorescence with fruits. **D**: Flower bud. **E**: Opening flower. **F**: Labellum. **G & I**: Petals. **H**: Dorsal sepal. **K & J**: Lateral sepals. **L**: Column. (Drawn by Dao Van Hoang)

Bulbophyllum dasystachys J.J.Verm., P. Thavipoke & J. Phelps, Phytotaxa 184 (1): 12–22, 2014**.** (Fig. 8)

Sympodial epiphytic orchid. ***Pseudobulbs*** occurred in groups connected by slender rhizome of ca. 0.4–0.5 cm diam., with much branched matted roots, ca. 1–2 cm apart, ovoid, ca. 1–2×1.2–1.5 cm. *Leaf* single, petiole; petiole –2–2.2 cm long; leaf blade elliptic-slightly oblong, ca. 8–13.5× 1.8–1.9 cm, acute. ***Inflorescence*** axillary from base of pseudobulb, patent elongated dense raceme, ca. 24 cm long; peduncle green, ca. 19 cm long; scales 4, elongate along peduncle, 1–1.5cm long, apex acuminate; rachis ca. 5 cm long, pubescent, with dark brown papillae; floral bracts green, linear, ca. 0.5–0.65 cm long, acuminate, hairy with minute brown hairs. ***Dorsal sepal*** free, pale green, pubescent with brown hairs, ovate with 1 mid veined, ca. 0.3–0.35×0.2–0.25 cm, apex acute, reflexed. ***Lateral sepals*** pale green, pubescent with brown hairs, ovate - somewhat triangular with 1 mid vein, 0.3cm×0.25 cm. ***Petals*** green, pubescent with long brown hair at the tip, triangular with slightly widen base, ca. 0.05–0.1×0.05 cm, acute. ***Labellum*** dark red, simple, pubescent along the margin, long brown hairs, oblong, ca. 0.3–0.35×0.2 cm, apex obtuse with green callus.; callus rounded, papillose, ca. 0.15 cm long; with an elongate mid-ridge down to

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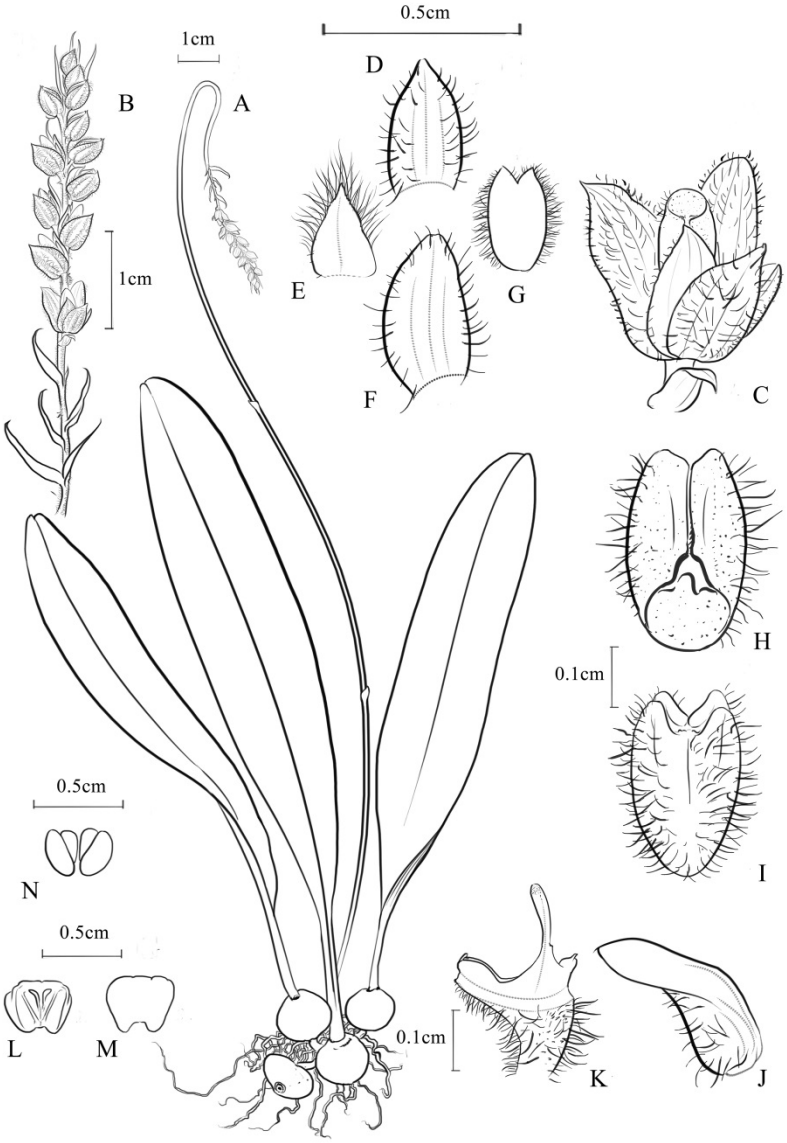


Fig. 8. Illustration of ***Bulbophyllum dasystachys*** J.J. Verm., P. Thavipoke & J. Phelps. **A**: Habit. B: Inflorescence. **C**: Opening flower. **D**: Dorsal sepal. **E**: Petal. F: Lateral sepals. **G**: Labellum. **H**: Labellum upper part. **I**: Labellum lower part. **J**: Labellum lateral view. **K**: Column. **L & M**: Anther. **N**: Pollinia. (Drawn by Dao Van Hoang)

the base of the labellum. ***Column*** greenish, strongly incurved, 0.3–0.35 cm long, including stelida; stelida white, falcate, ca.0.1cm long, obtuse; anther cap greenish-yellow; pollinia 4, 2 inner smaller than 2 outer, ca. 0.1 cm long, yellow. ***Ovary*** (plus pedicel) ca. 0.5–0.6 cm long, green, elongated with dark purple papillae ***Capsule*** not found.

Distribution: Thailand (type locality) and Vietnam

Ecology: Moist broadleaved evergreen montane forests, ca. 1450 m asl. Flowering September.

Note: The species has been known, so far, from the type with unknown locality and a photographic record without voucher specimen from Khao Yai National Park, Thailand as indicated in the original publication (J. J. Vermeulen, J. Phelps, & P. Thavipoke, 2014). This might be the first time that specimen collection of the mentioned species with known locality has been achieved in the present study. It is no doubt that the collected specimen belongs to this mentioned species though type specimen of this species had not been examined. This is due to the fact that the very detailed morphology in the original publication as well as a photograph in such original publication had indicated such distinct characteristic of the mentioned species. It is quite certain that this suppose–to–be rare species belong/or endemic to this Indo-China phytogeographic area, as Khao Yai Nation Park, Thailand where indicated in the original publication and the present locality in Hon Ba Nature Reserve are in more/less the same latitude. More collections in the Annamite range should be expected in future.

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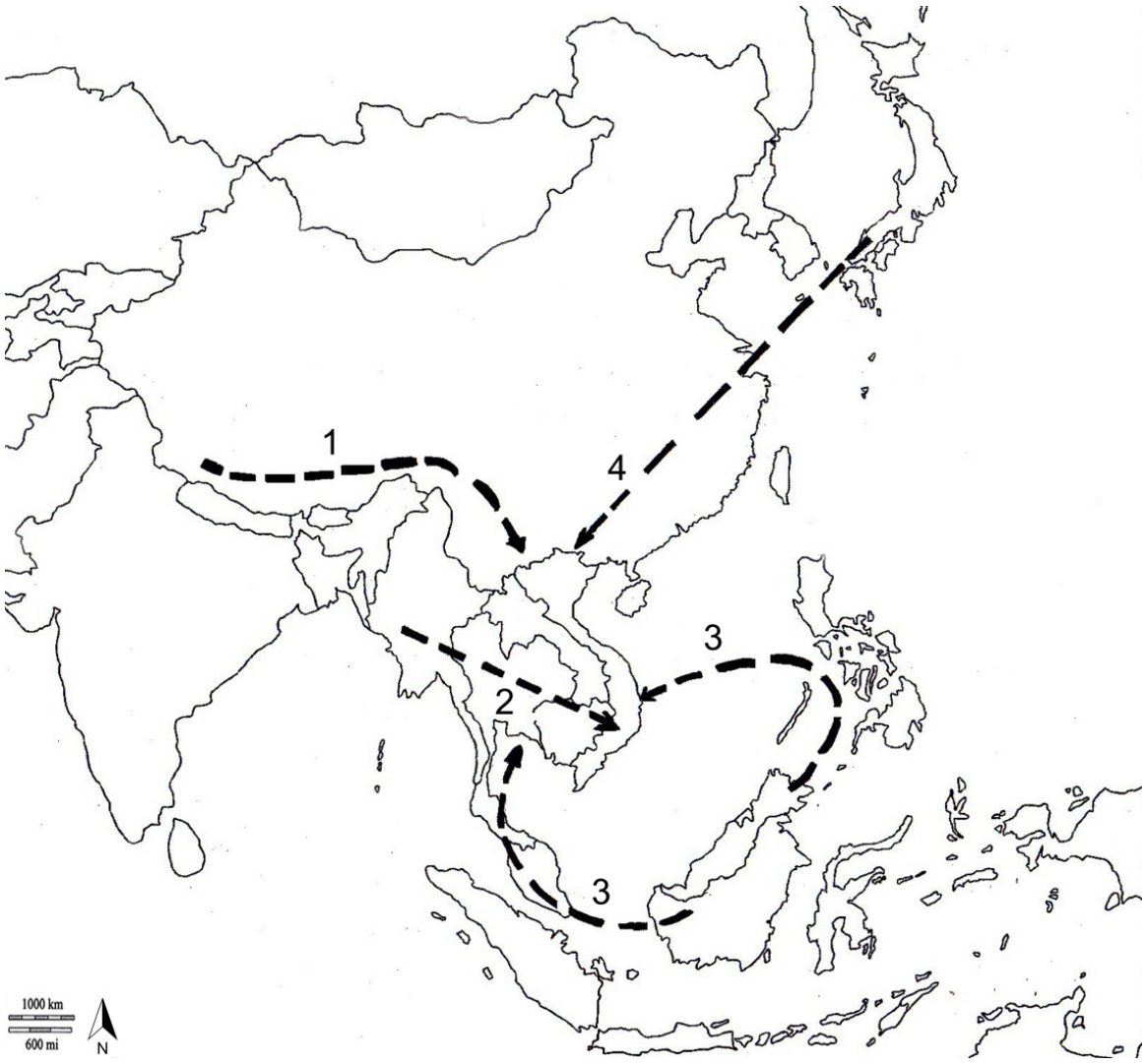


Fig. 9. Distribution patterns of orchids in different floristic regions.

DISCUSSIONS

The investigations of the orchid flora at Hon Ba Nature Reserve where is the part of the famous Annamite Range in Vietnam supported that the region is performing as a "cross road" for plant distributions from different nearby floristic regions. The different distribution patterns of orchid elements found at Hon Ba had shown that this mountain range could be considered on the one hand as an important "distribution bridge" for plants, especially for the elements that occurred in high altitude > 1,000 m asl. as the mentioned mountain range has connected various separate floristic regions (Himalayan region; The Indo-China region; Malesian region as well as sub-region of Sino-Japanese).

The direction of the proposed route of distribution had been decided by considering the ranges of the distribution of the majority of orchid taxa occurring in each region comparing to those recorded in the present study. The directions were designed due to the theoretical basis of the species and populations distribution in biogeography according to Lomolino *et al.* (2006) as well as Cox and Moore (2010). In constructing the concept of distribution patterns and directions of orchids found in Hon Ba Nature Reserve, as it is impossible to examine the specimens in such big regions, the different distribution routes had been, then, considered according to different distribution ranges which covered the possible areas where given taxa of orchids could be found due to the available literature. In this aspect, groups of orchids which occurred in Hon Ba Nature Reserve were categorized due to the geographical regions where such taxa had been already recorded then the location of Hon Ba Nature Reserve was taken in to account as to compare with those different distribution ranges. Logically, plants might distribute freely from inside the range to the edge concerning their distribution ranges and should not in

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the other way round. Though the distribution of a given species from the edge to the centre of a given distribution range is happening naturally, however, the range of distribution, when considering in a group of various taxa, should expand from the edge forwards and not vice versa. In such discipline, the possible distribution directions due to the geographical ranges of orchid elements found in this Nature Reserve had been, therefore, proposed (Fig. 9.).

Considering the orchids element found in this Nature Reserve, proposed routes of orchid distribution might be estimated according to the distribution ranges of different orchid elements:

1. The Himalayan route took place over the Himalayan southern branches down to the Annamite range (Fig.9).These could be seen from the common orchid elements which were recorded in the high altitude (> 1,000 m asl.) along the Himalaya in Nepal, Bhutan, Myanmar, Northern Thailand and Laos PDR and a part of the South of China. Such elements might share the centre of origin somewhere in the central or the east part of the Himalaya and distributed along such range to Vietnam as they have never been recorded in other neighboring countries in the South China Sea i.e. the Philippines, East China and/or Taiwan, moreover, none of those had been recorded in other parts of Thailand (except high mountain in the North) or even in Cambodia.
2. The Indo-China route that took place from west part of the Annamite Range crossing the Irrawaddy River Basin in Myanmar; Chao Praya River Basin in Thailand then continued through Korat Plateau in Thailand to the Annamite Range of Vietnam (Fig.9). On the other hand to the former issue, the orchid elements distributed along this route might have the Annamite range as their easternmost frontier of their distribution range, while this mentioned range goes westwards to the Irrawaddy River Basin in Myanmar. The centers of distributions of the plant elements in such area may fall into the Korat Plateau in the North-eastern part of Thailand. One newly recorded orchid species in the present study i.e. *Bulbophyllum dasystachys* J.J.Verm., P. Thavipoke & J. Phelps. is one of a good example of the recent described species from the Korat Plateau in Thailand (Khao Yai National Park) Vermeulen *et al.* (2014) that had also been just recorded in Vietnam in the present study.
3. The Malesian region route that could be separated into two pathways (Fig.9): one is the route that distributed through peninsular Thailand and Malaysia towards the South-eastern part of Thailand through Cambodia to Vietnam. The distribution along this one might take place either when the sea level was low enough that a land-connection between Vietnam and the Peninsular Thailand occurred or it could be also possible that the orchid elements might have distributed from Malay Peninsula along the Thai Gulf towards Cambodia to Vietnam. However, it is to be noticed here that the orchid elements of this distribution route had never been recorded from the Central Thailand or the Korat Platueu, the North-east of Thailand or even in Cambodia at all. And the other route took place in the West part of Borneo Isl. across the South China Sea to the Annamite range. In a similar way, the orchid elements of this distribution route had never been recorded from other places besides Borneo Isl. (in the Malesian region) and Vietnam. Only when the orchid flora investigation in Cambodia would be carefully achieved, the clearer information of how the elements which have their centre in the Malesian region had moved forward to the Annamite rage would probably take place as well.
4. The Sino-Japanese route that took place along the coast of China from Japan in the North, then towards the South to the Annamite range in Vietnam (Fig.9). However, the rage of the distribution of the orchid elements that falls into this category had included the Northernmost part of Northern Thailand, Myanmar and Laos PDR. Such orchid elements might have their "centers of distributions" somewhere along the southern coast of China up to Japan and end up with its southernmost limit in the South part of this Annamite range.

In additions, the Annamite range itself might also perform as a given (sub-) floristic region which could be seen from several endemic species that were recorded also from the study area.In order to draw much clearer picture of the phyto-geography in this Annamite range which has centered in Vietnam, more collections not only of orchid elements, but also other groups of plants in the whole Annamite Range would be, therefore, needed in future.

When considering the location of the Hon Ba Nature reserve (see also fig.9), the distribution patterns of the orchid found in that area had revealed that this famous Nature Reserve is situated more or less on the frontier of various orchid distribution patterns due to the phyto-geographic features of the region, therefore this "cross-road" of the distribution ranges seems to be rather important in terms of phyto-geography. And the most noticeable point concerning its location according to these distribution patterns of the orchid found might be that it had fallen into the northern limit of the famous Malesian region as well as the southern limit of the so-called "Sino Japanese" region. On the other hand, these various distribution patterns from the different floristic regions of Vietnam itself had created such unique orchid flora composition as well as other plant species in various given parts of Vietnam which had, somehow, been divided into different floristic provinces according to Averyanov *et al.* (2003). In any case, it is

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rather hesitated in the present study to group the orchid distribution patterns of the orchids found in the Hon Ba Nature Reserve into such proposed patterns of floristic provinces of Vietnam. It is due to the fact that Vietnam is a part of a large region so-called "Indo-China" which performed as one distinct region in terms of phyto-geography of the Mainland South-East Asia, which separated from other parts of Thailand (except the northern part of Thailand), the East of Myanmar and the Peninsular Malaysia. Any consideration of the floristic provinces in such region where Vietnam belongs to, might be more practice as well as realistic, when the comprehensive information on the plant diversity as well as the phyto-geographical data of a given group of plant e.g. orchids as in the present study etc., from other parts of the "Indo-China" i.e. Laos PDR, the North-Eastern part of Thailand (especially in the Korat Plateau) as well as Cambodia would be taken into account. Furthermore, it is such a pity that there is only a little information on the orchid flora in the neighboring countries to Vietnam of Laos PDR and the Kingdom of Cambodia due to their poor flora investigation in the past. It is to be convinced in the present study that the information of the orchid flora in Laos PDR as well as Cambodia might bring about the comprehensive understanding of the distribution patterns of the orchids of the Indo-China region as Laos PDR itself performed as a connection area of the distribution between China, Myanmar and Thailand to the Indo-China region while Cambodia is on the path of the distribution path from Malesian region towards Peninsular Thailand.

Suggestion on conservation.

As Hon Ba Nature Reserve is rather important as it performed as the "Biodiversity cross-road" of plants in the Indo-China Region, more information on the plant diversity in either plant groups in the area, including the adjacent ones would be useful in order to get much clearer phyto-geographic view point of the region of how plant diversity in a given area took place. Illegal native plants (including orchids) trade as well as habitat deterioration by many means, such as reforestation program, would soon deplete such biodiversity of the area. As the Hon Ba Nature Reserve is not only has important natural-historical value to Vietnam, however, it is one of those important jigsaws in order to make up the clearer picture of the phyto-geography of the Indo-China region as a whole. Moreover, more flora investigation and the intensive botanical surveys should be encouraged throughout the Indo-China region which also includes Vietnam, the Korat Plateau in the North-east of Thailand, Laos PDR as well as the Kingdome of Cambodia before the natural information on plant biodiversity would be destroyed by various anthropogenic activities e.g. habitat deteriorations, various reforestation programs etc.

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Appendix 1. List of Orchids in Hon Ba nature reserve with their distribution ranges.

Scientific name	Alt. (m) asl.[1]	Life form	Flowering time	Distribution									Voucher
				Cambodia	Himalayan ranges	Japan	Laos	Malesian region	Myanmar	South china	Thailand	Endemic	
Acanthephippium striatum Lindl.	1467-1500	T	Mar		X			X	X		X		BV029
Aerides falcata Lindl. & Paxton	800	E	Jul				X		X	X	X		BV034
Aerides odorata Lour.	980	E	Aug-Oct	X	X		X	X	X		X		BV035
Anoectochilus lylei Rolfe ex Downie	1501	T	Mar-Apr						X	X	X		BV030
Aphyllorchis pallida Blume	1167	S	Jul-Aug					X			X		BV036
Appendicula gracilis Aver.	1322	E	Jun									X	BV032
App. hexandra (J. Koenig) J.J. Sm.	1318	L	May	X				X			X		BV031
App. reflexa Blume	1450	L	Apr	X			X			X	X		BV033
Arundina graminifolia subsp. *caespitosa (*Aver.) H. A. Pedersen & Schuit.	310	L	Dec-Mar	X			X	X				X	BV027
A. graminifolia subsp*. graminifolia* Hochr.	1200	T	Jan-Dec	X	X		X	X	X	X	X		BV028
Bulbophyllum apodum Hook. f.	1468	E	Apr	X	X		X	X	X	X	X		BV043
B. clipeibulbum J.J. Verm.	1412	E	May									X	BV039
B. dasystachys J.J.Verm., Thavipoke & J. Phelps	1450	E	Sep								X		BV041
B. delitescens Hance	1200	E	Sep		X					X			BV042
B. frostii Summerh.	1156	E	Jul									X	BV040
B. macranthum Lindl.	258	E	May	X	X			X	X	X	X		BV045
B. retusiusculum Rchb. f.	1130	E	May-Jul		X		X	X	X	X	X		BV038
B. simondii Gagnep.	1397	E	Apr									X	BV044
B. tixieri Seidenf.	1568	E	May									X	BV046
B. tortuosum Lindl.	1466	E	May		X		X	X	X		X		BV037
Calanthe angustifolia Lindl.	1498	T	Aug-Sep					X		X			BV052
C. lyroglossa Rchb. f.	1400	T	Jul-Aug	X	X	X	X	X	X	X	X		BV051
Campanulorchis globifera (Rolfe) Brieger	1400-1503	E	Apr								X		BV086
Cephalantheropsis longipes (Hook.f.) Ormerod	1517	T	Oct		X		X	X	X	X	X		BV054
Ceratostylis siamensis Rolfe ex Downie	1171	E	Jul-Aug	X			X				X		BV055
C. subulata Blume	986	E	Sep-Dec	X			X	X	X	X	X		BV057
C. tonkinensis Aver.	1523	E	Oct									X	BV056
Cleisocentron klossii (Ridl.) Garay	1490	E	Mar									X	BV050
Cleisostoma birmanicum (Schltr.) Garay	1415-1500	E	Jun						X	X	X		BV065
C. striatum (Rchb. f.) N.E. Br.	1002	E	Jul		X			X		X	X		BV063
C. williamsonii (Rchb. f.) Garay	1066	E	Jul	X	X		X	X	X	X	X		BV064
Coelogyne eberhardtii Gagnep.	1333	E	Jul									X	BV071
C. fimbriata Lindl.	1176	E	Jul-Aug	X	X		X	X	X	X	X		BV070
C. mooreana Rolfe	1536	E	May-Oct									X	BV069
Collabium chloranthum (Gagnep.) Seidenf.	1435	T	Jun									X	BV068
Conchidium pusillum Griff.	1417	L	Oct						X	X	X		BV087
Cordiglottis longipedicellata Joongku Lee, T.B. Tran & R.K. Choudhary	1200	E	Mar									X	BV058
Cryptostylis arachnites Blume.	1257	T	Apr	X	X		X	X	X	X	X		BV059
Cymbidium dayanum Rchb. f.	1400	T	Jul-Aug	X	X	X	X	X	X	X	X		BV062
C. erythrostylum Rolfe	1510	E	May									X	BV060
C. lancifolium Hook.	1297	T	May	X	X	X	X	X	X	X	X		BV061
Dendrobium aduncum Lindl.	1067	E	Jul		X		X		X	X	X		BV075
D. aloifolium (Blume) Rchb.f.	800	E	Apr	X				X	X		X		BV082
D. amplum Lindl.	1156	E	Oct	X	X				X	X	X		BV095
D. angustifolium (Blume) Lindl.	1521	E	Jun					X		X	X		BV098
D. crumenatum Sw.	200	E	Oct-Mar	X			X	X	X	X	X		BV080
D. dentatum Seidenf.	1323	E	Mar									X	BV079
D. farinatum Schildh. & Schraut	1353	L	Jul									X	BV073
D. hamatum Rolfe	1100	E	Sep									X	BV076
D. khanhoaense Aver.	1350	E	Jul									X	BV074

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Scientific name	Alt. (m) asl.[1]	Life form	Flowering time	Distribution									Voucher
				Cambodia	Himalayan ranges	Japan	Laos	Malesian region	Myanmar	South china	Thailand	Endemic	
D. pachyphyllum (Kuntze) Bakh. f.	320	E	Mar		X			X	X		X		BV078
D. pseudotenellum Guillaumin	1510	E	Oct							X			BV083
D. spatella Rchb. f.	944	E	Jun	X	X		X	X	X	X	X		BV072
Didymoplexis pallens Griff.	850	S				X			X	X	X		
Eria globulifera Seidenf.	1321	E	Oct		X	X		X		X	X		BV091
E. lactiflora Aver.	1544	E	Mar									X	BV084
E. obscura Aver.	246	E	May									X	BV089
E. tomentosa (J.König) Hook.f.	700	E	Mar				X		X	X	X		BV085
Erythrorchis altissima Blume	900	S	Sep-Dec	X	X	X	X	X	X	X	X		BV097
Gastrochilus calceolaris (Buch.-Ham. ex Sm.) D. Don	1486	E	Jun		X		X	X	X	X	X		BV099
P. delenatii Guillaumin	800	L	Mar									X	BV129
P. villosum var. annamense Rolfe	1421	L	Feb				X			X			BV166
P. x cribbii Aver.	1310	L	Jan							X			BV165
Pholidota chinensis Lindl.	1474-1550	E	Jun-Jul						X	X	X		BV133
P. leveilleana Schltr.	1420-1500	T	Mar							X			BV132
Phreatia densiflora Lindl.	1435	E	May					X			X		BV135
Platanthera singgalangensis (J.J.Sm.) Efimov	1520	T	May					X	X		X		BV134
Podochilus banaensis Ormerod	1470	L	Apr									X	BV129
P. microphyllus Lindl.	1443	L	Apr	X				X	X		X		BV131
Pteroceras teres (Blume) Holttum	322	E	Sep-Dec	X	X		X	X	X		X		BV136
Spathoglottis plicata Blume	1200-1500	T	Jan-Dec	X	X		X	X	X	X	X		BV137
Stichorkis compressa (Blume) J.J.Wood	1323	E	Jun					X					BV105
S. gibbosa (Finet) J.J.Wood	1006	E	Sep		X		X	X	X		X		BV110
Tainia cordifolia Hook.f.	900	T	Jun							X			BV139
Thecostele alata C.S.P. Parish & Rchb.f.	350	E	Sep		X		X	X	X		X		BV140
Thrixspermum centipeda Lour.	334	E	Sep-Dec	X	X		X	X	X	X	X		BV142
T. fragrans Ridl.	815	E	May									X	BV141
Trias nasuta (Rchb.f.) Stapf	330	E	Dec		X				X		X		BV148
Trichoglottis retusa Blume	246	E	Sep					X			X		BV144
T. seidenfadenii Aver.	250	E	May								X		BV145
Trichotosia microphylla Blume	267	E	Mar					X		X	X		BV147
T. velutina Kraenzl.	1215	E	Jul		X	X				X			BV146
Vanilla atropogon Schuit., Aver. & Rybková	235	T	Mar									X	BV150
V. yersiniana Guillaumin & Sigaldi	301	T	Mar									X	BV151
V. albida Blume	300	T	Mar						X		X		BV152
Zeuxine agyokuana Fukuy.	1538	T	Sep				X				X		BV149

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