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## THE GENUS *ERIA* LINDL. (ORCHIDACEAE JUSS.) IN VIETNAM

*The paper deals with the results of long-term investigation of genus Eria in Vietnam — one of the largest orchid genera in flora of Vietnam and in family Orchidaceae as a whole. Many representatives of the genus Eria are not only an important component of primary epiphytic and lithophytic plant communities, but also play an important role in national medicine and may successfully been cultivated as ornamental plants. The brief descriptions of main types of vegetation natural habitats of genus Eria, data about distribution and ecology of genus Eria, about the main lines of morphological evolution, adaptation and specialization of genus Eria are given. The results of geographic and florogenetic analyses of Eria species in Vietnam are given. The conservation status of species of the genus Eria in Vietnam was determined (according to classification IUCN)*

### Introduction

The genus *Eria* — is one of the largest orchid genera in flora of Vietnam and in family Orchidaceae as a whole. According to the modern researches, it includes 46 species in the territory of the country that represents 6 % of all orchids in Vietnam [1–4, 6]. This genus occupies in Vietnam the third place after *Dendrobium* and *Bulbophyllum*. Many representatives of the genus *Eria* have wide distribution in Vietnam and form an important integral component of primary epiphytic and lithophytic plant communities, typical for the majority of primary forests. Other species of this genus have circumscribed distribution, representing strict endemism. Such endemic

species represent a very sensitive element of the flora. They may be successfully used as markers in biogeography, in monitoring of protected territories and in analysis of anthropogenic changes observed everywhere in flora of the country.

It is necessary to underline, that the genus *Eria* exhibits the center of diversity in Indo-Chinese peninsula, where it is presented with all main sections and have representative species composition.

The genus *Eria* in Vietnam gives understanding of the main and most important lines of evolution, adaptation and specialization not only in the genus *Eria*, but also in all family Orchidaceae. The genus has the large value for modern phytogeographic analysis, study of florogenetic processes in Indochina, for deli-



mitation of main centers of local endemism and biodiversity, as well as for outline of desirable protected areas.

Many representatives of genus *Eria* are not only an important component of primary epiphytic and lithophytic plant communities, but also play an important role in national medicine and may successfully been cultivated as ornamental plants (Fig. 1–8).

#### The main types of vegetation and most typical habitats of species of the genus *Eria* in Vietnam

Monsoon tropical woods are most typical for Vietnam. The species of the genus *Eria* are plants of woods occurring almost exclusively in various types of primary forests. The flora of epiphytic orchids is very rich and includes about 10 species of the genus *Eria* on the type of evergreen broad-leaved lowland woods on alluvial soils, which exist now as a small fragments along the rivers. For such woods are characteristic wet rainy summer and dry winter. These woods usually are wet and highly close. The trees of the upper stratum belong to tropical families and their heights reach 30–35 m.

Evergreen and semideciduous broad-leaved and coniferous forests on ancient karst limestones at elevations up to 1000 (1400) m are richest in orchids and *Eria* species in Vietnam. The genus *Eria* is represented in these woods

approximately by 20 species, among which are lithophytes and epiphytes. The climate here differs in the hot and wet summer and very dry cool winter. At low elevation in these woods dominate broad-leaved trees, which are gradually replaced by conifers, such as *Pseudotsuga*, *Tsuga*, *Calocedrus* and *Pinus* on higher elevations. Lowland woods on acidic silicate soils have other species composition of the genus *Eria* and including about 12 species *Eria*. Usually such woods relatively wet and close, however in the south of the country semideciduous and deciduous dry woods and savanna woodlands frequently replace them. Beginning from heights 600–700 m, in these forests appear gymnosperms from such genera as *Podocarpus*, *Dacrycarpus* and *Dacrydium*. The special ecological group is presented here by 3 miniature species of the genus *Eria*, living in a peripheral part tree crowns, as well as 5 species with lithophytic mode of life.



Fig. 1. *Eria calcarea* V.N. Long et Aver.

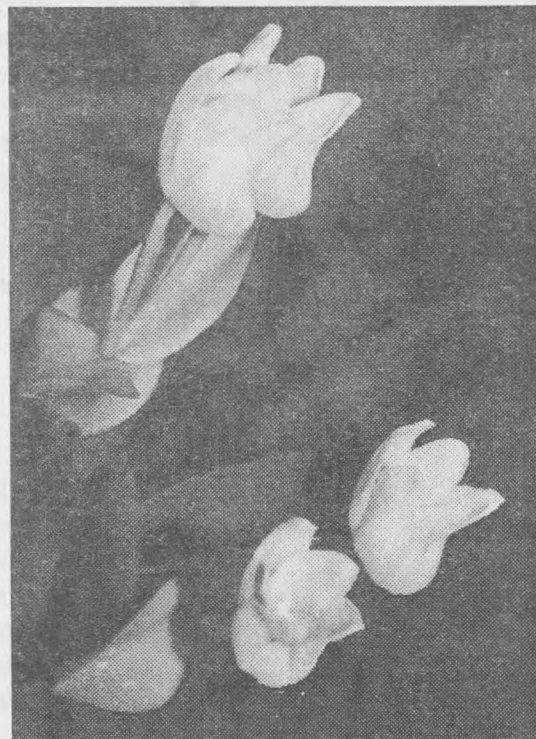


Fig. 2. *Eria lactiflora* Aver.

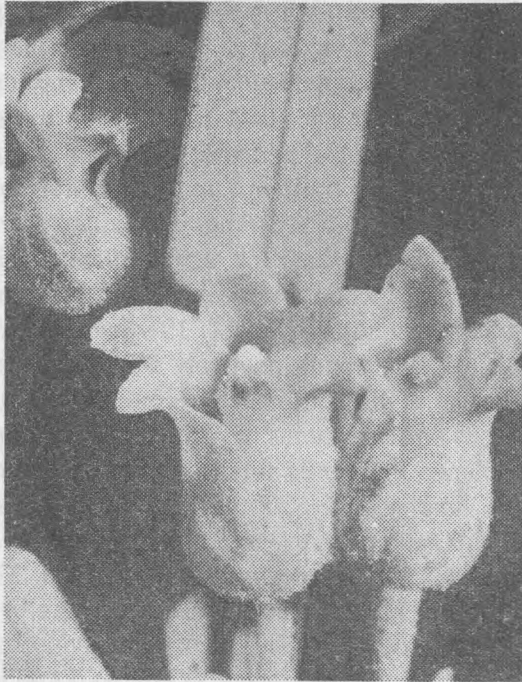


Fig. 3. *Eria foetida* Aver.

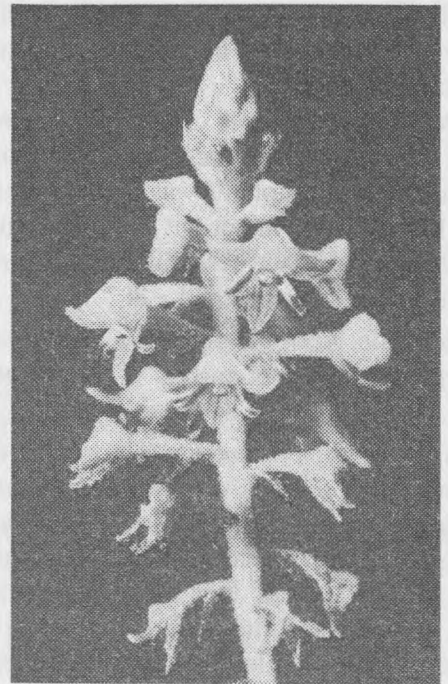


Fig. 4. *Eria obscura* Aver.

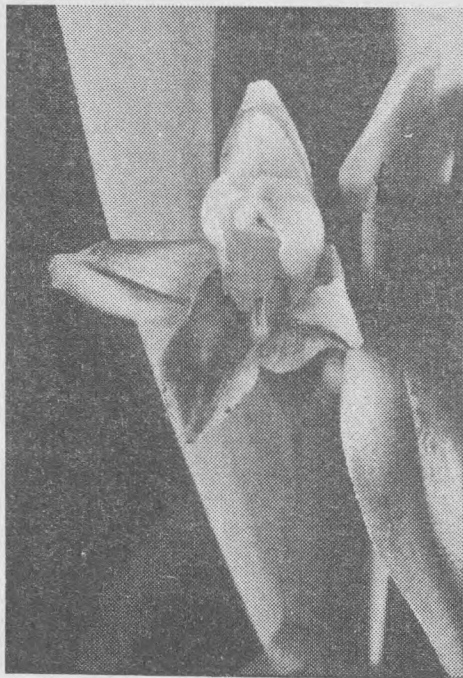


Fig. 5. *Eria carinata* Lindl.

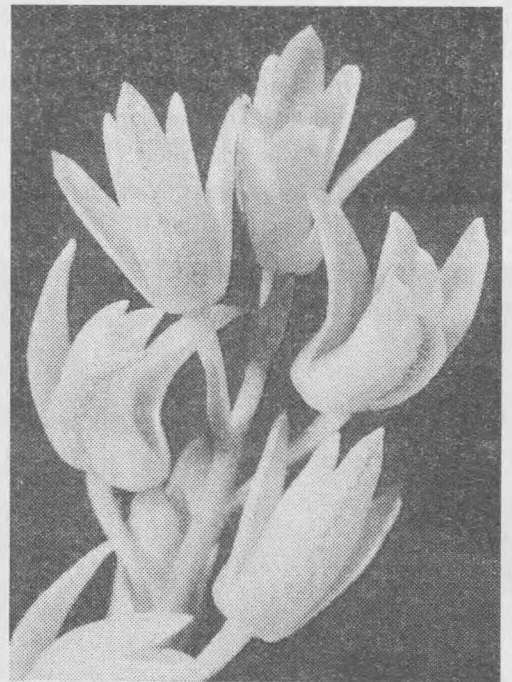


Fig. 6. *Eria gagnepainii* Hawkes et Heller





Fig. 7. *Eria globifera* Rolfe

There are about 15 species of genus *Eria* on the mountain and highland woods on acidic silicate soils, which are widely spread all over the country. The wet and cool climate caused predominance here of trees of subtropical families. Large tree ferns are very usual in such woods. The dry season is short. The high humidity defines in these forests abundance and diversity of epiphytes.

Coniferous trees become usual at the tops of mountain ranges. On montane slopes they reach 40 m height, and on mountain peaks form cloud forests with gnarled trees, commonly not higher than 10–12 m. In more dry conditions here dominate *Dacrycarpus*, *Dacrydium*, *Keteleeria*, *Pinus kesiya*, *P. merkusii*, and in more wet — *Fokienia*, *Cunninghamia*, *Nageia*, *Podocarpus*, *Tsuga*, *Pinus krempfii* and *P. dalatensis*. The distinct dry season here is not present. The species composition of epiphytes is not rich due to low winter temperatures, but the abundance of epiphytic plants is high. To this group, besides other orchids, belong about 8 species of the genus *Eria*.

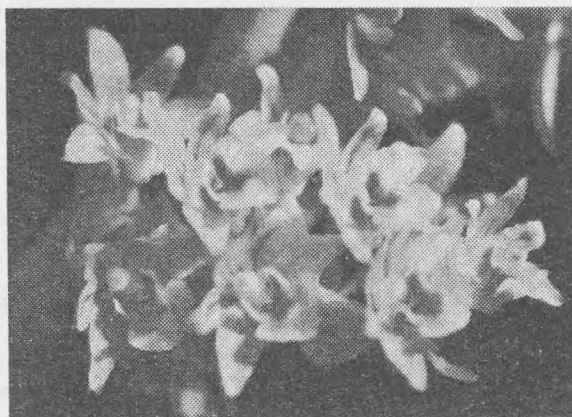


Fig. 8. *Eria diversicolor* V.N. Long et Aver.

Dry semideciduous woods and the savanna woodlands spread wide in the south of the country at elevations 0–500 m, where prevails semiarid climate with the long dry season. In wood undestory the xerophytic grasses and bamboos dominate. Orchids here are not too various. The genus *Eria* is represented in these woods by two species both of which, however, are strict endemics.

For other plant communities wide spread in territory of Vietnam (shrub, herbaceous, mangrove communities, swamps, various secondary groupings etc.), the species of the genus *Eria* are not characteristic and meet as infrequent exception.

#### Geobotany, distribution, ecology and protection of species of the genus *Eria* in Vietnam

The flora of Vietnam is typical flora of Paleotropic Kingdom numbering about 10350 species, which belong to 2256 genera and 305 families. From them about 750 species and 135 genera fall into to family Orchidaceae, largest family in the flora of the country. All species were ranged into geographical groups on the base of their distribution, which reflect their natural history and migrations (Table 1).

Very large diversity of natural conditions, habitats and types of environment of Vietnam

Types of Vietnamese *Eria* species distribution

Type of species distribution	Species names	%
4.1. South-Asian group	4 species:	8.7 %
4.1.1. South-Asia-Malesia	<i>Eria bractescens</i>	2.2 %
4.1.2. South-Asia-Sundaic	<i>Eria biflora</i> , <i>E. lasiopetala</i> , <i>E. pannea</i>	6.5 %
4.3. Indochina-Malesian group	3 species:	6.5 %
4.3.1. Indochina-Malesian	<i>Eria floribunda</i>	2.2 %
4.3.2. Indochina-Sundaic	<i>Eria oblitterata</i> , <i>E. tenuiflora</i>	4.4 %
4.4. SE. Asia mainland group	39 species:	84.8 %
4.4.1. E. Himalaya-SE. Asian (mainland)	<i>Eria acervata</i> , <i>E. amica</i> , <i>E. apertiflora</i> , <i>E. bambusifolia</i> , <i>E. carinata</i> , <i>E. clausa</i> , <i>E. corneri</i> , <i>E. coronaria</i> , <i>E. muscicola</i> , <i>E. paniculata</i> , <i>E. pusilla</i> , <i>E. tomentosa</i>	26.1 %
4.4.2. S. Chinese	<i>Eria crassifolia</i>	2.2 %
4.4.3. E. Himalaya-Indochinese	<i>Eria dacrydium</i>	2.2 %
4.4.4. Malay-Indochinese (mainland)	<i>Eria bipunctata</i> , <i>E. eriopsidobulbon</i> , <i>E. globifera</i> , <i>E. globulifera</i> , <i>E. perpusilla</i> , <i>E. siamensis</i> , <i>E. sutepensis</i> , <i>E. truncata</i>	17.4 %
4.4.5. Indochinese (except Malay Peninsula)	<i>Eria donnaiensis</i> , <i>E. gagnepainii</i>	4.4 %
4.4.6. Vietnamese	<i>Eria bidupensis</i> , <i>E. boniana</i> , <i>E. calcarea</i> , <i>E. carunculosa</i> , <i>E. cochinchinensis</i> , <i>E. diversicolor</i> , <i>E. foetida</i> , <i>E. lactiflora</i> , <i>E. lanigera</i> , <i>E. longipes</i> , <i>E. obscura</i> , <i>E. pulverulenta</i> , <i>E. simondii</i> , <i>E. spirodela</i> , <i>E. thao</i>	32.6 %

supports a highest level of a biodiversity and high level of plant endemism, especially in Orchid family (endemics in flora of the country represent about 10 % of species and 3 % of total number of genera). The genus *Eria* presents important component of floras of wet tropical regions of Southeastern Asia and includes in Vietnam 46 species. It represents 6 % of all Vietnamese orchids, which from them 15 species (32.6 %) are endemics of Vietnam.

As a whole florogenetic analysis of species of the genus *Eria* gives a pattern of floristic connections, justified for all flora of the country. In this respect the orchid flora of Vietnam (including species of the genus *Eria*) reveals closest floristic connections with the East Himalayas, southwest part of Indochinese peninsula, including Malay Peninsula, and southern China. Less connection are observed with Philippines and Sunda islands. The largest group of *Eria* species is formed by strict endemic species (Table 1). Such species in

Vietnam are 15 that present 32.6 % of a species composition of the genus *Eria*, represented in flora of the country.

Six floristic districts or floristic provinces are defined and accepted on the base of phytogeographic, geological, geomorphologic and climatological data on the territory of Vietnam. The greatest species diversity of the genus *Eria* is observed in South Annamese province (29 species, from them 6 are endemics of this province), and also in Central Annamese (22 and 1), South Chinese (21 and 1) and North Indochinese (20, no one endemic) provinces. Relatively poor species composition is observed in South Indochinese (17 and 2) and Sikang-Yunnan (14 and 2) provinces.

The species of the genus *Eria*, occurring in Vietnam, may be separated into 3 ecological groups: (1) the species of the first group prefer wet evergreen broad-leaved and coniferous forests on limestone, which widespread in north of the country. (2) The species of other group grow in mountain regions of cen-



tral and southern Vietnam, where the acidic silicate rocks, sandstones or shifts prevail. (3) The species of the third group do not show the obvious preference to the certain substrate (Table 2). On their mode of life the species of the genus *Eria* in Vietnam are divided on epiphytes (42 species), lithophytes (14 species) and terrestrial plants (2 species). The part of species inhabits a mountain belt at elevation 800–1500 m above sea level (28 species), at elevations 0–800 may be found 13 species, and the same number of species live in highlands as high as 1500–2500 m a.s.l. For 9 species the elevation range of habitats was not fixed. The species of the genus *Eria* in Vietnam prefer regions with a high level of atmosphere precipitations, which, however, usually is seasonal, therefore plants develop adaptations for survival during more or less long drought (Table 2).

Now majority of species of the genus *Eria* in Vietnam rapidly die out as a result of the uncontrolled collecting and destruction of their habitats.

All species of the genus, especially strict endemics, need protection all over the country. About 16 species of the genus *Eria* are very rare plants, 7 — rare; all of them are known on one or several old findings and now are very close to extinction. The species sometimes reported as common, actually, are rather common only in restricted territories of survival pieces of primary woods, but not all over the country. According to criteria of classification IUCN, 1 species of the genus *Eria* in flora of Vietnam is endangered, 15 species are vulnerable, and 13 species belong to the group of lower risk and deficit data for an estimation of the status for 17 species. The protection of species of the genus *Eria*, as well as other orchids, must include a lot of measures, such as the qualified research of the flora for discovery of existing populations, organization of protected areas and their monitoring, edition of the verified Red data book, prohibition of

the collecting of plants for commercial purposes, wide public education of necessity of conservation of rare species as national treasure (Table 2).

#### Generic and infrageneric classification and evolution of the genus *Eria*

The genus position is defined as: Fam. *Orchidaceae* Juss., Subfam. *Epidendroideae* Lindl., Trib. *Epidendreae* Humb., Bonpl. et Kunth, Subtrib. *Eriinae* Benth., Genus *Eria* Lindl. The genus *Eria* is the largest genus of subtribe and includes 350–400 species. Genus *Eria* in flora of Vietnam represented by 13 sections and 46 species.

Different directions of the evolution, which have determined formation of the sections of the genus, represented in Vietnam are analyzed as following:

(1) The section *Bambusifoliae* appears in the genus as the most primitive on the base of combination of numerous very primitive features. Probably it is ancestral group.

(2) The formation of not swollen short stem with distichous conduplicate leaves, and lip of quite complicated structure covered with papillae, imitating pollen grains, has resulted in formation of species of the section *Mycaranthes*.

(3) One of the main evolutionary tendencies consists in formation of cylindrical little thickened pseudobulbs consisting of 2 internodes; the apical internodes in this case are shortened and two leaves approach on an apex. Such phenomenon is characteristic for sections *Polyura*, *Secundae* and *Trichosma*. Most primitive among them are the section *Polyura*, having simple petaloid lip, and section *Secundae* with a simple lip bearing poorly visible callosities. More advanced section of this group is the section *Trichosma*. The lip in species of this section gets complex of lamellate keels and much reduced flower bracts that appear as hardly visible scarious scales. The most advanced species of section form almost orbicular pseudobulbs.

Data on ecology and status of *Eria* species in the flora of Vietnam

Species name	epi- phyte	litho- phyte	terre- strial	Si substrate	Ca substrate	0- 800 m	800- 1500 m	1500- 2500 m	status	occu- rence
1. <i>E. acervata</i>	+			+	+		+		VU	nr
2. <i>E. amica</i>	+			+		+	+	+	LR	nr
3. <i>E. apertiflora</i>	+			+	+		+		VU	nc
4. <i>E. bambusifolia</i>	+			—		—	DD	vr		
5. <i>E. bidupensis</i>	+			+				+	DD	R
6. <i>E. biflora</i>	+			+		+	+		DD	vr
7. <i>E. bipunctata</i>	+			+			+	+	VU	nc
8. <i>E. boniana</i>	+	+			+		+		LR	nr
9. <i>E. bractescens</i>	+			+		—	DD	vr		
10. <i>E. calcarea</i>	+	+			+		+		VU	nr
11. <i>E. carinata</i>	—	+			+		+		VU	r
12. <i>E. carunculosa</i>	+	+		+		—	DD	vr		
13. <i>E. clausa</i>	+	+		+	+		+		DD	r
14. <i>E. cochinchinensis</i>	+			+		—	DD	vr		
15. <i>E. corneri</i>	—	+		+	+	+	—		LR	c
16. <i>E. coronaria</i>	—	+	+	+	+		+		LR	vc
17. <i>E. crassifolia</i>	+	+			+	+			VU	nc
18. <i>E. dacrydium</i>	+			+			+	+	DD	vr
19. <i>E. diversicolor</i>	+			+			+		DD	r
20. <i>E. donnaiensis</i>	+			+		—	DD	vr		
21. <i>E. eriopsidobulbon</i>	+			+				+	VU	nr
22. <i>E. floribunda</i>	+			+			+	+	VU	r
23. <i>E. foetida</i>	+			+	+		+		VU	o
24. <i>E. gagnepainii</i>	—	+	+	+	+	—	+		LR	nr
25. <i>E. globifera</i>	+	+		+	—	—	+	+	LR	nr
26. <i>E. globulifera</i>	+	—		—	+		+	+	LR	nr
27. <i>E. lactiflora</i>	+			+			+	+	VU	r
28. <i>E. lanigera</i>	+			—			+		DD	vr
29. <i>E. lasiopetala</i>	+	—		+	+	+			LR	nr
30. <i>E. longipes</i>	+			+		—	DD	vr		
31. <i>E. muscicola</i>	+			+			+		DD	vr
32. <i>E. oblitterata</i>	+			+		+			DD	vr
33. <i>E. obscura</i>	+			+		+			VU	o
34. <i>E. paniculata</i>	+	—		+	+		+	+	LR	vc
35. <i>E. pannea</i>	+			+	+	+	+		LR	nr
36. <i>E. perpusilla</i>	+			+		+			EN	vr
37. <i>E. pulverulenta</i>	+			+		—	DD	vr		
38. <i>E. pusilla</i>	+	+		+	+		+		VU	nr
39. <i>E. siamensis</i>	+	—		+	+		+	+	LR	nr
40. <i>E. simondii</i>	+			—	—	—	DD	vr		
41. <i>E. spirodela</i>	+	+		+	+	+			VU	vr
42. <i>E. sutepensis</i>	+	+		+	+		+		VU	o
43. <i>E. tenuiflora</i>	+			+		—	—	—	DD	vr
44. <i>E. thao</i>	+			+	+		+	+	LR	nr
45. <i>E. tomentosa</i>	+	+		+	+	+			LR	nr
46. <i>E. truncata</i>	+			+			+	+	VU	r

*Explanations for the table:* first three columns (from the left to the right) means epiphytic, lithophytic or terrestrial mode of life recorded for *Eria* species; next two columns mean preferences of the species to substrates developed on silicate acidic rocks (granite, rhyolite, quartzite, andesite, silicate sandstone etc.) and on solid crystalline limestone; next three columns mean elevations reported for habitats of the species — in meters; last two columns mean status species in the wild (according to IUCN categories: EN — endangered, VU — vulnerable, LR — lower risk, DD — deficit data and species rarity (vr — very rare, r — rare, nr — not rare, nc — not common, o — occasional, c — common, vc — very common); “—” — data are absent.





(4) The sections *Cylindrolobus*, *Hymenaria*, *Pinalia* and *Urostachya* represent central trunk in evolution of the genus. For this evolution line is typical successive thickening and oligomerization of shoot to formation of large fat pseudobulbs, formation of colored flower bracts and complicating of lip structure. The lip gets the complex structure specific to each of listed sections. Lip of species of the sections *Cylindrolobus* and *Hymenaria* is distinctly lobulate with various keels of a complex structure and large colored flower bracts. Pseudobulbs of the most advanced species of last section become almost orbicular. The special type of a lip is characteristic for sections *Pinalia* and *Urostachya*. Lip of species of the first section has massive junction with column-foot, and inflorescence becomes head-like. For species of the second section are characteristic the lateral lobes of a lip connected by the high transversal connective, that forms cup-like structure similar to wide nectary (Fig. 9).

Highest level of oligomerization of orthotropic shoots is typical for species of sec-

tions *Dendrolirium*, *Strongyleria* and *Xiphosium*. Section *Dendrolirium* occupies the central place in this group. Here is observed the changes of pseudobulbs form from cylindrical to almost spherical one, consisting of 2–3 internodes. Leaves in some species become succulent. This tendency increases in some species of section *Strongyleria*, when leaves become cylindrical, taking up function of a reserving of water. Pseudobulbs at such species are not formed. In the second group of species of section *Strongyleria* is observed the maximal oligomerization of orthotropic shoot, which is represented by orbicular juicy pseudobulbs, consisting from one node. Pseudobulbs with one terminal leaf are characteristic also for section *Xiphosium*. Flowers of species of this section have wing-like keels on lateral sepals that are a unique feature of very high specialization.

General miniaturization has led to formation of section *Conchidium*, which looks quite heterogeneous on its origin and morphology. A deep reduction and metamorpho-

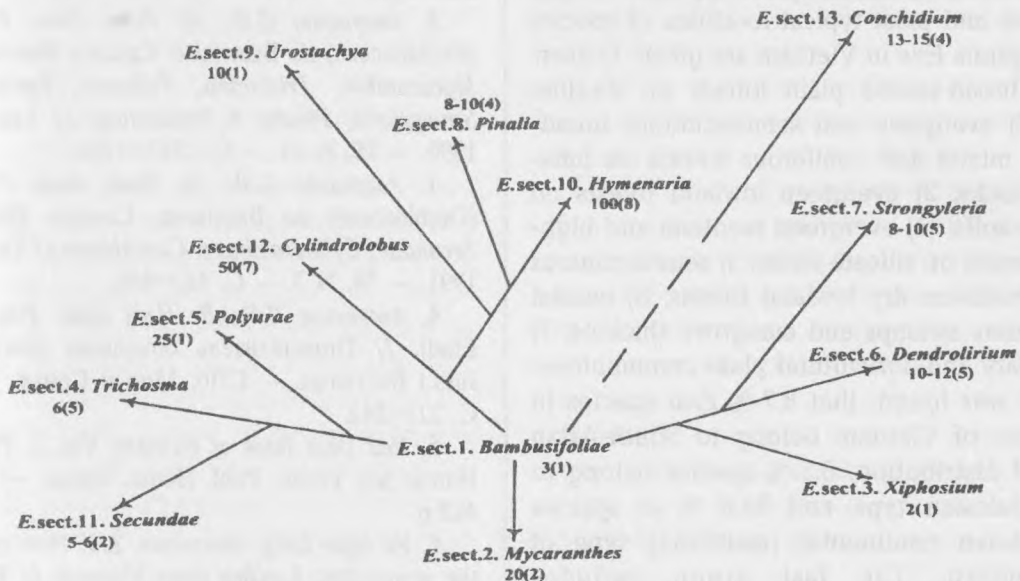


Fig. 9. The scheme of phylogenetic relationships of main sections of the genus *Eria*, represented in Vietnam flora



sis of all members with partly or complete reduction of leaves is observed here. Green flattened pseudobulbs carry in species of the section function of photosynthesis. In every respect species of this section give an example of the highest specialization not only in the genus *Eria*, but also in all Orchidaceae family.

#### Main issues and discussion

- Strict correlation of a diversity of species of the genus *Eria* with a high level and constancy of humidity of habitats during all year is revealed; climatic features of the territory of a habitation of the genus *Eria* with revealing of 7 types of a climate, which are: 1) monsoon tropical climate with cool winter and summer rains; 2) with cool winter and summer – autumn rains; 3) with warm winter and winter – autumn – winter rains; 4) with warm winter and autumn – winter rains; 5) with warm winter and summer rains; 6) monsoon sub-equatorial climate with summer rains; 7) monsoon tropical mountain climate.

- It was found that the greatest diversity of *Eria* species is observed in primary mountain forests at medium elevations. The 7 main types of vegetation (identical with 7 types of climate features) and most typical localities of species of the genus *Eria* in Vietnam are given: 1) evergreen broad-leaved plain forests on alkaline soils; 2) evergreen and semideciduous broad-leaved mixed and coniferous forests on limestone rocks; 3) evergreen lowland forests on silicate soils; 4) evergreen montane and highland forests on silicate rocks; 5) semideciduous and deciduous dry lowland forests; 6) coastal vegetation, swamps and mangrove thickets; 7) secondary and agricultural plant communities.

- It was found, that 8.7 % *Eria* species in the flora of Vietnam belong to South-Asian type of distribution, 6.5 % species belong to Indo-Malesian type and 84.8 % of species have Asian continental (mainland) type of distribution. The last group includes species with E. Hymalaya-SE. Asian distribu-

tion (26.1 % of species), S. Chinese distribution (2.2 %), E. Hymalaya-Indochinese distribution (2.2 %), Malay-Indochinese continental (mainland) distribution (17.4 %), Indochinese distribution (4.4 %) and strict endemic Vietnamese distribution (32.6 %). Such florogenetic allocation of *Eria* species reflects character of all flora of Vietnam and confirms its very high level of endemism.

- It is found the circle of status problems of species of genus *Eria* Vietnam, that the majority of endemic species needs protection.

- The main evolutionary tendencies in the genus *Eria* were outlined on the base of detailed morphological studies. These defined ways of morphological evolution were used as a base for infrageneric classification, which resulted of 13 sections of the genus, 46 species. In the flora of Vietnam 15 species of the genus are strict endemics of the country (including two species, described as new to a science).

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PIД ERIA LINDL. (ORCHIDACEAE JUSS.)  
У В'ЄТНАМІ

Ву Нгок Лонг

Національний Центр природничих наук і технології В'єтнаму, Центр екології, природних ресурсів і навколишнього середовища інституту тропічної біології, В'єтнам, м. Хошимін

У статті викладено результати багаторічного всебічного дослідження роду *Eria* Lindl. у В'єтнамі — одного з найбільших родів орхідей флори В'єтнаму і родини Orchidaceae в цілому. Багато представників роду *Eria* є не лише важливою складовою первинних епіфітних та літофітних рослинних угруповань, а й становлять значний практичний інтерес як лікарські та декоративні рослини. Наведено стислі описи основних типів рослинності місць природного зростання роду *Eria*, відомості щодо поширення та екології видів роду *Eria* у В'єтнамі, головні напрями морфологічної еволюції, адаптації та спеціалізації цього роду. Представлені результати географічного і флорогенетичного аналізу видів роду *Eria* у В'єтнамі. Дано оцінку статусу видів роду *Eria* як рослин, що потребують охорони (відповідно до класифікації IUCN).

ПОД ERIA LINDL. (ORCHIDACEAE JUSS.)  
ВО ВЬЕТНАМЕ

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В статье изложены результаты многолетнего всестороннего изучения рода *Eria* Lindl. во Вьетнаме — одного из крупнейших родов орхидей флоры Вьетнама и семейства Orchidaceae в целом. Многие представители этого рода не только являются важнейшей составляющей первичных эпифитных и литофитных растительных сообществ, но также представляют значительный практический интерес как лекарственные и декоративные растения. Приведены краткие описания основных типов растительности мест природного обитания видов рода *Eria*, сведения о распространении и экологии видов рода *Eria* во Вьетнаме, об основных направлениях морфологической эволюции, адаптации и специализации этого рода. Представлены результаты географического и флорогенетического анализа видов рода *Eria* во Вьетнаме. Дана оценка статуса видов рода *Eria* как растений, нуждающихся в охране (в соответствии с классификацией IUCN).