

# The problems of infrageneric classification of *Eulophia* R. Br. ex Lindl. (Orchidaceae, Cymbidiinae)

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**Abstract:** The genus *Eulophia* comprises about 230 species. It has a wide distribution range – from tropical and subtropical Africa and Madagascar, through Asia to Australia; one species occurs also in tropical America. For 723 records found for *Eulophia* in the International Plant Name Index, more than 500 are probably synonyms. Infrageneric classification of the genus is also complicated by the morphological diversity. We have to deal with situation where problematic species, not matching terms of smaller and well defined allied genera, are arbitrarily included into *Eulophia*. Proposed infrageneric classification will be based upon methods of classical taxonomy, particularly examination of generative and vegetative characters. Additionally, the results of examination will be compared with data obtained from molecular studies and scanning electron microscopy (SEM). Phylogenetic analysis will utilize nucleotide variation among sequences of selected DNA markers, preferably Internal Transcribed Spacer of nrDNA multigene family. Those will be followed by biogeographic analysis with focus on methods of phylogenetic biogeography. Precise study of genus *Eulophia* is essential to access the limits of many species and to propose sectional arrangements for the entire range.

**Key words:** *Eulophia*, phylogenesis, ITS, classification, SEM, Orchidales

## 1. Introduction

The order Orchidales became an object of intensive research using both traditional and modern methods. Increasing devastation of tropical plant formations induces taxonomic and floristic treatments, that will make it possible to estimate a degree of species biodiversity. There is still a large group of taxa insufficiently examined, with their taxonomic position being imprecise. The detailed studies of each genera and their qualified species are essential for the correct estimation of their homology.

One of such genera is *Eulophia* R. Br. ex Lindl. It comprises probably over 230 species widespread from tropical and southern Africa and Madagascar, through tropical and subtropical Asia, Australia, with one species occurring in tropical America (Thomas 1998). The genus is highly diverse, occupying the wide range of habitats. For 723 records found in International Plant Name Index for *Eulophia*, about 500 are synonyms. Comprehensive sectional arrangement for the genus does not exist, with only 48 species being placed within formal infrageneric groups.

Representatives of the genus occur in the wide range of habitats. Most of them grow terrestrially in the savanna and scrub, but epiphytic species can also be found in grasslands and in the lowland and equatorial forest. Majority of species exhibit sympodial growth, except for *Eulophia epiphytica* from Madagascar, which is monopodial and should probably be placed in a separate genus (Cribb *et al.* 2002).

Infrageneric classification of the genus is also complicated by its morphological diversity. Perennating organs may be pseudobulbous or tuberlike. Leaves are thin but tough, narrow and grass-like, or lanceolate and plicate. Some species lack green leaves and are saprophytic. Two types of flowers occur within *Eulophia*. In the first type, the sepals and petals are very similar in size, shape and color. In the second one, the sepals are much smaller than the petals and often recurved. In both types, the lip extends into a spur which can be very diverse in shape. Form of the flower, especially spur, results from the adaptation to different pollinators. For example genus *Pteroglossaspis* Rehb.f. was distinguished from *Eulophia* on the basis of the lack of a spur. The lip is mostly three-lobed, with crests, and/

or papillae on upper surface, and often with basal callus appendages. Lip can be connated with column, which is arcuate, with or without a column foot. Presence or absence of a column foot seems to be an important character in an infrageneric treatment of *Eulophia*. Pollinia are in number of four or two, likewise in the genus *Cymbidium* Sw. (Szlachetko 2003).

Problems with exact delimitation of genus *Eulophia* leads to a situation when problematic species, not matching terms of smaller and well defined allied genera, are arbitrarily included into this genus.

## 2. Infrageneric classification

Genus *Eulophia* was formally described by John Lindley in 1823 within Botanical Register. Few years later, in 1833, he proposed three sections. Section *Genuinae* Lindl. contained 19 species, from which three were transferred to the genus *Graphorkis* Thouars, and one species, *Eulophia artrovirens* Lindl. was placed in the genus *Oeceoclades* Lindl. (Garay & Taylor 1976). Four species from section *Desciscentes* Lindl. are now included in the genus *Acrolophia* Pfitzer. Three species from section *Aphylae* Lindl. are considered now synonyms of *Eulophia dabi* (D. Don) Hochr. (Thomas 1998).

In 1833 Lindley described genus *Cyrtopera*, which was distinguished from *Eulophia* on the basis of presence of a column foot. *Cyrtopera* contained 9 species: *C. plantaginea* Lindl., *C. woodfordii* Sims, *C. scabrilinguis* Lindl., *C. flava* Lindl., *C. obtusa* Lindl., *C. bicarinata* Lindl., *C. plicata* Lindl., *C. pedicellata* (L.f.) Lindl. and *C. gigantea* (L.f.) Lindl. Currently, *Cyrtopera* is included into *Eulophia*, although some authors (Hooker 1890) suggested that it should possess the status of a section.

Kraenzlin (1897) described section *Pulchra* that contained *Eulophia pulchra* (Thouars) Lindl. and the most similar species. List of names for that section was published by Garay and Taylor in 1976, although most of them is presently considered as synonyms of *E. pulchra*.

The most recent infrageneric classification was proposed by Perrier de la Bâthie (1935), who revised Madagascar group of *Eulophia* species. He distinguished three sections. First section, *Saprolophia*, contained only one species, *Eulophia hologlossa* Schltr.; second section – *Lissolophia*, was composed of seven species. Third section, *Eulophia*, contained 25 species, with most of them currently included in genera the *Graphorkis* and *Oeceoclades*. In 1941, Perrier de la Bâthie transferred all *Eulophia* species to the genus *Lissochilus*, and raised

sections *Lissolophia* H.Perrier and *Eulophidium* Kraenzl. to subgeneric level. He also distinguished subgenus *Stiriolophia*. Presently, taxa from section *Lissolophia* are placed in section *Eulophia*, *Eulophidium* is considered to be synonymous with *Oeceoclades*, and species from the subgenus *Stiriolophia* are now distributed to *Eulophia* and *Graphorkis* (Thomas 1998).

Since the revision of Perrier de la Bâthie, there were no attempts to propose a different infrageneric treatment of the genus. In 1965, Hall analyzed South African species of genus *Eulophia* with methods of numerical taxonomy and proposed groupings, but without any arrangement of sections. Cribb (1989) made a number of groupings within East African species of *Eulophia*. Although he did not propose any ranks or sections, the results of his studies could be a basis for proposing a new infrageneric classification of the genus.

## 3. Proposed materials and methods

Proposed infrageneric classification will be based upon methods of classical taxonomy. The specimens, mostly type specimens, borrowed from herbaria and other scientific units, will be examined, photographed and measured. Flowers will be drawn, measured and described. The most essential will be studies of the structures covering the lip (crests, papillae and callus), presence and length of the column foot, presence and shape of the spur, size and shape of the sepals and petals, diversity of perennating organs and leaves. Data about distribution and ecology of the species will also be gathered. For examination of morphology and ultrastructure of floral elements responsible for secretion, scanning and electron transmission microscopy (SEM, TEM) will be used.

Phylogenetic analysis will be based on nucleotide variation among sequences of selected DNA markers, preferably Internal Transcribed Spacer of nrDNA multi-gene family. The ITS sequence was efficiently used in phylogenetic studies of closely related taxa at generic level (Cox *et al.* 1997; Ryan *et al.* 2000; Gravendeel *et al.* 2001).

Data collection will contain as many as possible sources of information concerning classical or molecular systematic. It will be possible to conduct examination of taxa distribution with methods based on principles of both cladistic and phylogenetic biogeography. Biogeographic analysis will be based upon currently gathered literature materials and results of original research.

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