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Checklist of mycoheterotrophic species of the genus *Exacum* (Gentianaceae) and new species, *E. zigomorpha*, from northern Vietnam

LEONID V. AVERYANOV[1], KHANG SINH NGUYEN[2] & HIEP TIEN NGUYEN[3]

[1]*Komarov Botanical Inst., Russian Academy of Science, Prof. Popov Str. 2, 197376 St Petersburg, Russia. E–mail: av_leonid@mail.ru*
[2]*Inst. of Ecology and Biological Resources, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet, Cau Giay, Ha Noi, Vietnam; Key Laboratory of Plant Resources Conservation and Sustainable Utilization, South China Botanical Garden, Chinese Academy of Sciences, Guangzhou 510650, PR China. E–mail: khangnguyensinh@yahoo.com; nskhang@gmail.com*
[3]*Center for Plant Conservation, no. 25/32, lane 191, Lac Long Quan, Nghia Do, Cau Giay District, Ha Noi, Vietnam. E–mail: hiep.nguyen@cpcvn.org*

Abstract

The paper provides a key for identification and a checklist of mycoheterotrophic species of the genus *Exacum*, representing a well-defined group of achlorophyllous members of Gentianaceae regarded sometimes in the limits of a separate genus *Cotylanthera*. One novel species, *E. zygomorpha*, discovered in northern Vietnam, is described and illustrated as new for science. Among other features the discovered species strikingly differs from its congeners in having distinctly zygomorphic flowers.

Introduction

The group of mycoheterotrophic, achlorophyllous species of the genus *Exacum* L. (1753: 112) presently includes 5 species from tropical Asia from Nepal and Bhutan through China, Indochina and Indonesia to the Philippines and New Guinea. This group recognized in the past as the genus *Cotylanthera* (Blume 1826), forms a well-defined group of mycoheterotrophic achlorophyllous members of the Gentianaceae, which since their discovery (Blume 1826) were traditionally regarded in a separate genus (Gray 1869, Clarke 1883, Gilg 1895, Lace 1914, Smith *et al*. 1921, Hara 1975). The most recent taxonomic treatment (Hara 1975) summarized the specimens available in herbaria and provided adequate data about morphology, diagnostic features and distribution of the 4 species of the group recognized at that time. Important new details on the distribution of some mycoheterotrophic species were reported in the following publications: Ho Ting-nung & Pringle (1995), Hul (2003) and Biswal *et al*. (2011). One of the first monographers of the Gentianaceae proposed tentative inclusion of *Cotylanthera* as a section within the widespread and variable genus, *Exacum* Linnaeus (1753: 112) (Baillon 1891). More than a century later this idea received some support from molecular investigations that suggested mycoheterotrophic *Cotylanthera* species are nested inside *Exacum* (Yuan *et al*. 2003, Merckx *et al*. 2013). In response, species of *Cotylanthera* were transferred into *Exacum* with necessary nomenclatural name changes (Klackenberg 2006). At the same time, molecular studies revealed specific characters of *Cotylanthera* species that make correct phylogenetic analysis fairly problematic (Yuan *et al*. 2005). Because of these findings the present taxonomic position of the genus remains uncertain. It seems reasonable to recognize this specific group of species as a distinct separate group based on the possible evolution of *Exacum*–like ancestors produced through paraphyletic derivation and through the evolution of the mycoheterotrophic mode of life and degradation of its photosynthetic system. The achlorophyllous habit in mycoheterotrophic species here strongly correlates with the formation of slender dwarf stems, tuberous roots (lacking root hairs) and deep reduction of leaves as happens in many similar mycoheterotrophic evolutionary lines of flowering plants (Leake 1994). It is notable that all members of the genus are very rare unattractive plants easily overlooked in botanical surveys and poorly represented in world herbarium collections. This explains why there are extensive and essential gaps in our knowledge about the genus. In this connection the new species described and illustrated here represents a significant missing link in global understanding of the evolution of the genus, its specialization, diversity and distribution. The paper also provides a key for identification and a checklist of all currently known mycoheterotrophic species of *Exacum* summarized from all presently available data.

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