



## Two new species of *Rhodiola* (Crassulaceae) from the Qinghai-Tibetan Plateau

JIAN-QIANG ZHANG<sup>1</sup>, SHI-YONG MENG<sup>2\*\*</sup> & GUANG-YUAN RAO<sup>2\*</sup>

<sup>1</sup>College of Life Sciences, Shaanxi Normal University, Xi'an 710119, China

<sup>2</sup>College of Life Sciences, Peking University, Beijing 100871, China

\* Corresponding author: [rao@pku.edu.cn](mailto:rao@pku.edu.cn) (G. Y. Rao), \*\*Co-first author.

### Abstract

Two new species, *Rhodiola daochengensis*, and *Rhodiola tricarpa* (Crassulaceae) were described from the Qinghai-Tibetan Plateau, China. *Rhodiola daochengensis* was placed in sect. *Rhodiola* due to its dioecy, cymose inflorescences, and sessile, serrate stem leaves. It shares close morphological affinity with *R. kirilowii* which is supported by the ITS data but differed from the latter in the morphology of leaves (amplexicaul, cordate at base of leaves), flower stems, and pedicel (with densely glandular-pubescent) and fruits (apical beak recurved strongly). *Rhodiola tricarpa* is unique for its tricarpellary pistil and belongs to sect. *Chamaerhodiola* due to its dioecy and elongate flowering stems. It shares morphological affinity with *R. coccinea*, *R. fastigiata* and *R. tangutica* but differs in caudex leaves (dimorphic), and flowers (3-merous).

**Key words:** cpDNA, Crassulaceae, new species, nrDNA ITS, *Rhodiola daochengensis*, *Rhodiola tricarpa*

### Introduction

*Rhodiola* L. is a genus of about 70 species, distributed mainly in the Himalaya and SW China (Fu and Ohba 2001; Mayuzumi and Ohba 2004). It's distinguished from related lineages (*Sedum* L., *Hylotelephium* H. Ohba, *Phedimus* Rafinesque) by the well-developed rhizomes and the annual flowering stems arising from the axils of the scaly radical leaves. The species diversity of this genus is especially high in the western alpine regions (i.e., the Hengduan Mountains and the Qinghai-Tibetan Plateau) of China (Fu and Ohba 2001). *Rhodiola* species have been used as an important adaptogen, hemostatic, and tonic in traditional Tibetan medicines for thousands of years (Yang *et al.* 1991; Rohloff 2002). As a result, many species of this genus are severely endangered in Asia due to excessive and indiscriminate exploitation (Yan *et al.* 2003; Lei *et al.* 2006).

Species of *Rhodiola* display a high level of morphological diversity, which has made the infrageneric classification controversial (Ohba 1978, 1981a, b, 1982; Fu and Fu 1984; Fu and Ohba 2001). Several taxonomists used different sets of morphological characters to treat taxa of *Rhodiola* as subgenera, sections and series (Schönland 1890; Preager 1921; Berger 1930; Borissova 1939; Ohba 1978, 1981a, b, 1982). Ohba (1978, 1981a, b, 1982) established a most comprehensive classification of the genus, recognizing four subgenera (*Rhodiola* subgen. *Primuloides* H. Ohba, *R.* subgen. *Crassipedes* H. Ohba, *R.* subgen. *Rhodiola*, and *R.* subgen. *Clementsia* H. Ohba) based on radical leaves, dioecy, and inflorescence types. Zhang *et al.* (2014a) conducted a phylogenetic study of *Rhodiola* based on three molecular markers (*ITS*, *psbA-trnH* and *trnL-F*), and revealed that most of these infrageneric classifications were not monophyletic. This may be caused by rapid radiation in the middle and late Miocene (Zhang *et al.* 2014b).

From 2009–2014, we undertook extensive field research in Xizang (Tibet), Sichuan, and Yunnan Provinces and collected many specimens of *Rhodiola*. Two specimens could not be identified as any existing species of *Rhodiola*, according to *Flora of China* (Fu and Ohba 2001), *Flora Xizangica* (Fu 1985), *Flora Sichuanica* (Wu et Wu 2012), *Flora Yunnanica* (Zhuang 1997), *Flora of Nepal* (Ohba and Rajbhandari 2012), *The Flora of British India* (Clarke 1896), *The Flora of Pakistan* (Sarwar 2002), *Flora of Bhutan* (Grierson 1987) and *Illustrated handbook of Succulent Plant: Crassulaceae* (Ohba 2003). Here, we describe these as two new species, *Rhodiola daochengensis* J.Q. Zhang et G.Y. Rao, and *Rhodiola tricarpa* S.Y. Meng et G.Y. Rao. We also assessed the relationships of the two new species with other *Rhodiola* based on geographical distribution, morphology, and DNA sequence data.