

Cistanche deserticola

Orobanchaceae

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Summary

***Cistanche deserticola* Ma is illustrated and described. The species is native to China where it has long been valued and used in Traditional Chinese Medicine, and is now cultivated extensively for trade. The species is confused easily with closely related species such as *C. salsa* (C.A. Mey.) Beck. Bract and vascular bundle morphology, and habit, have been used traditionally to discriminate these taxa, which we discuss. *Cistanche deserticola* and its relatives may have significant global potential as ancillary crops that could be grown with shelter forests, planted to halt land degradation.**

Cistanche deserticola Ma belongs to the genus *Cistanche* (Orobanchaceae), comprising some 20-30 accepted species, all of which are holoparasitic (parasitic plants that lack chlorophyll). The species is distributed in North and North West China, in sandy desert areas dominated by halophytic shrubs. Two species of *Haloxylon* (family Amaranthaceae), *H. ammodendron* (C.A. Mey.) Bunge ex Fenzl and *H. persicum* Bunge have been described as its host species (Song et al. 2020). The name *Cistanche deserticola* was applied in 1960 by Ma Yuquan (b.1916-d.2008), at that time a lecturer at Inner Mongolia University. In 1935, Ma was in his third year of study at the Biology School of Peking University when the Second Sino-Japanese War broke out. He applied for military service, returning to his studies and to a distinguished career in botany after five years in the army. Ma went on to establish a herbarium at Inner Mongolia University (HIMC), to become Secretary-general of the Botanical Society of China, and to edit the Flora of Inner Mongolia. Despite being described relatively recently, *C. deserticola* is now a plant of

significant commercial importance, and the ecological and economic benefits of its cultivation are beginning to be released on a growing scale.

Cistanche deserticola is used medicinally and traded under the names of as Rou Cong Rong or desert ginseng, and has been attributed aphrodisiac and immune-boosting effects. Concerns about the impact of wild harvesting *C. deserticola* for the medicinal market led to its inclusion in CITES appendix II annotation #1, meaning that wild-harvested material cannot be traded internationally. The medicinal market has driven significant investment in the cultivation of species which are considered to be medicinally important. According to the Chinese Pharmacopoeia (CP; China Pharmacopoeia Commission, 2015), these are *C. deserticola*, *C. tubulosa* (Schenk) Wight ex Hook.f, and *Cistanches herba*, a name which refers to the dried fleshy stems sourced from either species (China Pharmacopoeia Commission, 2015). Though not included in the CP, another Chinese species, *C. salsa* is recognised by two provincial pharmacopoeias, the Ningxia Chinese Materia Medica Standards (Ningxia Health Bureau, 1993) and the Gansu Chinese Materia Medica Standards (Gansu Food and Drug Administration, 2009).

Differentiating the CITES-listed species *Cistanche deserticola* from other species is necessary to enforce the CITES legislation as it currently stands. *C. deserticola* is readily discriminated from naturally occurring *C. sinensis* which is occasionally wild harvested and enters trade (Thorogood et al., 2021); the species has a strong and characteristic blue tint upon drying. *C. deserticola* is also easily distinguished from co-occurring putative *C. tubulosa*, the other species recognised by the CP, which is cultivated in the Xinjiang province of northwest China. It differs from *C. deserticola* in several characters including colour and pubescence (*C. tubulosa* is yellowish and virtually glabrous); indeed even the traded dried stems can be differentiated because of differences in vascular bundle morphology; those of *C. deserticola* are star-like where as those of *C. tubulosa* are scattered (China Pharmacopoeia Commission, 2015; Tu et al., 2016; Plate 1 and Plate 2). Although clearly a different entity, there is considerable doubt about whether the correct name is applied to this cultivated pharmacopoeial species. Gilbert and Leon (pers obs 2016), noted that plants cultivated commercially in Xinjiang do not match verified herbarium specimens of *C. tubulosa* from Africa and the Middle East and coined the provisional name *Cistanche* 'Tamarisk' for these (Leon and Lin, 2017). *Cistanche laxiflora* may prove to be the correct name for this taxon, since DNA sequence data from the type specimen of *Cistanche laxiflora* indicates a close relationship between accessions identified as *C. tubulosa* from China (Ataei et al., 2020).

Discriminating *C. deserticola* from *C. salsa* is much more difficult. According to the Flora of China, the two species differ in bract and corolla colour. *C. deserticola* is described as having bracts and corolla subequal in length whereas the bracts of *C. salsa* are half as long as the corolla (Flora of China, eFloras 2008). Bract shape is also used to discriminate between the species: the bracts of *C. deserticola* are linear

lanceolate or lanceolate, whereas those of *C. salsa* are ovate lanceolate. Finally, whether the corolla dries brown (*C. deserticola*) or yellow-white (*C. salsa*) is considered to be a useful character. In the field, most local botanists identify the two species by size and host, with *C. deserticola* considered to parasitise *Haloxylon* species exclusively, and to have a more robust habit. Whether such differences are fixed, as would be expected if these are genetically distinct entities that should be assigned species status, is unclear. Our observations in the field suggest that bract characters are unreliable, with the relative length of corolla and bract varying both developmentally and continuously among mature specimens. There are anatomical differences, for example in *C. deserticola* the vascular bundle tips extend into a tail, while those of *C. salsa* lack an extension (Tu & Guo, 2015; Plate 1 and Plate 2A and 2B). Recent studies also identified differences in sugar composition between *C. deserticola* and *C. salsa* (Wang et al, 2019). It is possible that the differences in the colour of the dried corolla could be a result of different sugar profiles, or due to the influence of the host species. Host-driven speciation has been observed in other genera in the Orobanchaceae, where incipient species or races parasitizing different hosts can be obscured by cryptic morphology (Thorogood & Hiscock, 2010). It is unclear whether any differences between *C. deserticola* and *C. salsa* are fixed, as would be expected if these are diverged entities that should be assigned species status. Existing phylogenies show that they are sister species (Piwowarczyk et al., 2021, Ataei et al., 2020), but whether the case of *C. deserticola* and *C. salsa* is one of host-driven speciation can only be resolved using DNA sequence data from plants sampled rigorously from known hosts across their ranges.

In Inner Mongolia, *Cistanche deserticola* is particularly well known, and recognised as a valuable local product. In a field trip to the region in May 2019 four of the authors were able to observe first-hand how the wild plants are valued by local people (Plate 3A). We observed that plants in the wild were closely monitored by members of the local community, who pile up sand to increase the size of the growing stems. They also protect the plants from poachers, and at harvest time, remove only a proportion of the stems so they can harvest stems every year (Plate 3A, 3B). Harvested stems are entered into competition, and ultimately enter local trade where the largest plants have great prestige (Plate 3C and 3D); we found one substantial stem for sale for approx. 8000 Chinese Yuan in a shop in the town of Badanjilin (Plate 3E). The high value of the plants has driven advances in cultivation, with particularly significant advances made by the research group of Professor Tu Pengfei from the Peking University School of Pharmaceutical Sciences. Extensive plantations of *C. deserticola* have been established (Plate 4, Plate 5), and these have significantly increased the quantities of *C. deserticola* entering the Chinese markets. The value of these cultivated plants in trade is expected to reach 20 billion Chinese Yuan in the coming years (Song et al., 2020). Cultivation of *C. deserticola* as an ancillary crop on the species planted to limit desert encroachment has also contributed to sustainable desert-control and provided a new source of income for the people of the Alxa Desert. The increased supply of *C. deserticola* has driven a

diversification of its commercial uses, to include herbal teas, cosmetics and dietary supplements as well as medicines (Song et al., 2020). Taking a global perspective, we recently described the potential for *Cistanche deserticola* and its relatives as ancillary crops grown alongside shelter forests to halt land degradation more widely, based on the plants' successful cultivation in China (Thorogood et al., 2021). We suggest that global expansion of *Cistanche* farming should be informed by robust taxonomy so that the properties of the various species, and their cultivation potential, are defined objectively.

Description (adapted from the Flora of China, 2008)

A robust, achlorophyllous herb 0.4-1.6 m tall. Stems unbranched or 2-4-branched, 2-10 cm in diam. Leaves reduced to scale-like bracts; those on lower part of stem ovate or triangular-ovate, 0.5-1.5 X 1-2 cm; bracts on upper part lanceolate or linear-lanceolate, 2-4 cm X 5-10 mm, glabrous. Inflorescence a spike, 15-50 cm; bract sub-equalling corolla, ovate-lanceolate or lanceolate, along with bracteoles and corolla sparsely pubescent abaxially; bracteoles ovate-lanceolate or lanceolate, sub-equalling calyx. Calyx campanulate, 1-1.5 cm; lobes 5, ca. 2.5 X 3-5 mm. Corolla pale yellow-white, flushed to a variable degree with pale purple, becoming brown when dry, tubular-campanulate, 3-4 cm, apex 5-lobed; lobes 4-6 X 6-10 mm. Filaments 1.5-2.5 cm, base villous; anthers long ovoid, 3.5-4.5 mm, densely villous, base mucronate. Ovary ellipsoid, ca. 1 cm. Style glabrous, usually persistent; stigma sub-globose. Capsule ovoid-globose, 1.5-2.7 X 1.3-1.4 cm. Seeds ellipsoid or ovoid, 0.6-1 mm. $2n = 40^*$.

Distribution

Native to China where it occurs 200-1200 m above sea level in Gansu, Inner Mongolia, Ningxia, Xinjiang; also known from Mongolia. Rare and endangered in the wild but now cultivated extensively.

Habitat and Ecology

Sandy deserts dominated by halophytic shrubs including *Haloxylon ammodendron* and *H. persicum*.

Etymology

The name *Cistanche deserticola* was applied in 1960 by Ma Yuquan (b.1916-d.2008), a lecturer at Inner Mongolia University. The specific epithet refers to the plant's preference for desertic environments.

Flowering Time

May to June depending on locality, rainfall and altitude (generally fruiting July to August).

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Figures and Plates.

Plate 1 Vascular bundles of *Cistanche deserticola* seen in stems in cross section. 1A, 1B and 1C material of a traded specimens in section. 1D Vascular bundles discernable in a fresh dissected stem of *Cistanche deserticola*.

Plate 2 Diagrams of the vascular bundles of four *Cistanche* species represented at two scales. Left diagrams show the details of each vascular bundle, white arrows indicating the phloem, black arrows, the xylem. Right diagrams illustrate the vascular bundle arrangement in gross stem cross sections. 2A *C. deserticola*, 2B *C. tubulosa*, 2C *C. salsa* and 2D *C. sinensis*.

Plate 3

3A Wild *Cistanche deserticola* prior to harvest, only a portion of stem will be removed from the host in this sustainably managed population. 3B Harvesting a blooming *Cistanche* plant. 3C, 3D Stems sold in a *Cistanche* trading fair in China. 3E Fresh *Cistanche* stems valued at 8000 Chinese Yuan each, for sale in the town of Badanjilin; note the two lowermost stems of *Cynomorium songaricum* Rupr (often sold together with *Cistanche*).

Plate 4-5. *Cistanche* cultivation on a farm in Alxa, Inner Mongolia, China.

Plate 6 Species of *Cistanche* that grow in China. 6A. Putative *C. salsa* (showing the typical squat habit cited to be an important diagnostic); 6B. *C. sinensis*; 6C. *C. 'Tamarisk'* (= *C. tubulosa*), depicting the lax inflorescence, which in life, is whitish-cream-coloured and distinct from the Middle Eastern yellow form of the species (see Figure 2E); 6D. *C. deserticola*, showing the typical long, dense inflorescence; 6E. The dried stem of *C. deserticola* traded as 'Rou Cong Rong'. Reproduced from Thorogood et al., (2021).

Plate 7 *Cistanche deserticola*. 7A. Pistil. 7B. Stamen. 7C. Corolla in profile. 7D. Emergent buds (immature stems). 7E. Fruiting capsule in cross section. 7F. Calyx. 7G. Corolla (front view). 7H. Corolla in cross section.

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