

637. FRITILLARIA YUMINENSIS

Liliaceae

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Summary. *Fritillaria yuminensis* X.Z. Duan (*Liliaceae*) is described and illustrated; the species in the *Fritillaria verticillata* complex are listed and their relationship to the rest of the genus, as revealed by DNA studies, is described. The cultivation of *Fritillaria* (bei mu) for medicine and its conservation in China are summarised.

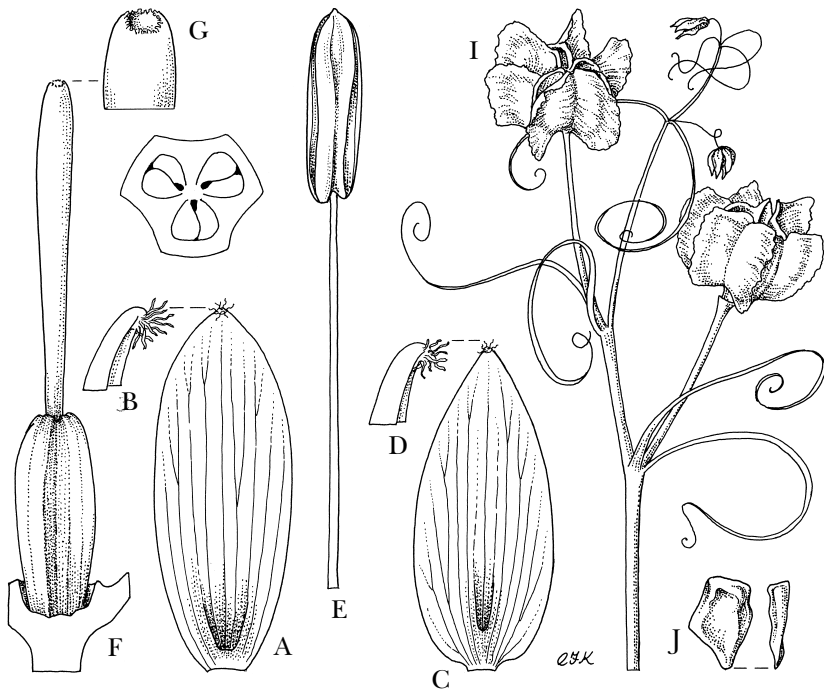
The bulbs of *Fritillaria*, called bei mu, are one of the most popular herbal medicines in China, and are collected in the wild throughout the country, and even in neighbouring areas. Kingdon Ward, while describing his travels in northern Burma in 1931, describes teams of 20 or more Chinese collectors coming over the Himalaya to collect bulbs of *Fritillaria cirrhosa* D. Don (Kingdon Ward, 1937). The bulbs are collected while the plants are flowering, dried, powdered and used as an infusion or made into pills. Several species are cultivated for Traditional Chinese Medicine in different parts of China, and the species illustrated here was discovered in the course of research in the 'Experiment station of fritillaries' in Yumin county, in western Xinjiang 834800.

Fritillaria yuminensis was described in 1981 by Duan Xian-Zhen from specimens which he collected and cultivated near Yumin. Its flowers were described as *caerulei*, but this is somewhat wishful thinking, though they are a beautiful pale lilac to palest pink; as many as 20 are produced on a good specimen. The stem leaves are narrow and whorled, without curled tips; the bract leaves are very narrow and coil around any available support. The flowers are rather conic in shape, from a narrow, squarish base; the tepals are pointed and more or less equal; the style is entire or divided only at the tip. The nectary is small and insignificant, but the scent is sweet, like *Hyacinthus orientalis* L., and the flowers attract small bees, which also collect the pollen. The small nectary and use of pollen as the attractant for insects is unusual in the genus *Fritillaria*.

Two colour forms of *Fritillaria yuminensis* have been described, var. *albiflora* X.Z. Duan & X.J. Zheng, and var. *roseiflora* X.Z. Duan & X.J. Zheng, and a third, var. *varians* Y.K. Yang & G.J. Lin, of which

we have seen no specimens. *Fritillaria tachengensis* X.Z. Duan & X.J. Zheng and its variety var. *nivea* Y.K. Yang & S.X. Zhag are also considered to be minor variations of *F. yuminensis*. *F. tachengensis* was described from Tarbagatai mountains near Tacheng, as being close to *F. verticillata* Willd., but with smaller, 'blue' flowers; it seems very close to *F. yuminensis*, if not identical with it.

Fritillaria yuminensis belongs to the complex of species related to *F. verticillata*, found in the Altai and in the mountains on the border of Xinjiang and Kazakhstan (Rix, 2005). As this area has become better known botanically, other species have been discovered. *Fritillaria albidiflora* X.Z. Duan & X.J. Zheng, with small, flat flowers was described from near Tacheng, and a white-flowered plant, rather similar to *F. yuminensis* has been given the cultivar designation 'Kara-sumbi', after the locality where it was collected. *Fritillaria verticillata* Willd., with



***Fritillaria yuminensis*.** A, outer perianth segment, $\times 2$; B, apex of outer perianth segment, $\times 8$; C, inner perianth segment, $\times 2$; D, apex of inner perianth segment, $\times 8$; E, stamen, $\times 4$; F, gynoecium, $\times 4$; G, stigma, $\times 8$; H, t.s. ovary, $\times 6$; I, infructescence, $\times 1$; J, seed, 2 views, $\times 2$; drawn by Christabel King from specimens received from Duan, X-Z.



Plate 637 *Fritillaria yuminensis*

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large, pure white flowers and narrow leaves, is known from the Altai in Russia, Kazakhstan, China and Mongolia. *Fritillaria tortifolia* X.Z. Duan & X.J. Zheng, also wild near Yumin, has very large flowers, white, tessellated with crimson, and somewhat broader leaves than *F. verticillata*.

A recent and very interesting find in this area has been *Fritillaria thunbergii* Miq., described by Thunberg in 1784, as *Uvularia cirrhosa* Thunb., from specimens cultivated in Japan (Mathew, 2000). This has long been grown for medicine in China in the central and eastern provinces of Jiangsu, Anhui, Zhejiang and Hunan, and predominantly Zhejiang; it has also been grown in Japan, where it is known to be naturalised, but its native habitat and range have always been uncertain. Its discovery by Arnis Seisums, in the Tarbagatai mountains in Kazakhstan on the Xinjiang border, close to these other similar species, suggests that the eastern Chinese records of the species in the wild may also be escapes from cultivation, and that it may have been an early import to eastern China from the west.

The phylogenetic relationships of *Fritillaria* with other genera of Liliaceae (Fay & Chase, 2000; Rønsted *et al.*, 2005; Fay *et al.*, 2006) and within *Fritillaria* (Rønsted *et al.*, 2005; Leitch *et al.*, 2007; De Graaf, O'Reilly, Leitch & Fay, unpublished results) have been the subject of research at Kew since the 1990s. In addition to clarifying relationships, these studies have been aimed at improving our understanding of genome size evolution. *Fritillaria* species have some of the largest genome sizes (the amount of DNA in each nucleus) of any plants; tetraploid *Fritillaria assyriaca* Baker, for example, has an astonishing 38 times more DNA than *Prosartes smithii* (Hook.) Utech, Z.K. Shinwari & S. Kawano (also Liliaceae; Leitch *et al.*, 2007).

The genus *Fritillaria* is monophyletic and sister to *Lilium* (including *Nomocharis*). At the current level of sampling, *Fritillaria* is split into two main groups (or clades): (1) subgenus *Liliorhiza* (the North American species plus *Fritillaria camschatcensis* Ker Gawl. (North America and eastern Asia) and *Fritillaria maximowiczii* Freyn (Asia); and (2) all the other Eurasian species. In the Asian clade, *Fritillaria davidii* Franch. is relatively isolated, and the remaining species form two clades, again following a basically geographical pattern, one comprising (at least predominantly) eastern Asian species and the other the European and western Asian species.

Here we are interested in the first of these clades, made up of *Fritillaria* subgenera *Petilium*, *Korolkowia* and *Japonica* and eastern Asian species of subgenus *Fritillaria* (the European and western Asian members of this subgenus are in fact not closely related and the subgenus needs to split into at least two groups as a result).

Fritillaria persica L. (subgenus *Theresia*) may also be a member of this clade, but this result needs corroboration. At the present level of understanding, the exact relationship between *F. yuminensis* and the other members of this clade is unresolved, but it appears to be relatively close to *F. verticillata* and the closely related species *F. pallidiflora* and *F. tortifolia*. *Fritillaria thunbergii*, on the other hand, may be more closely related to subgenera *Petilium* and *Korolkowia*, but this again needs corroboration.

Fritillaria yuminensis itself has been found only in northwestern China, in the Maili mountains south of Yumin and the Tarbagatai mountains north of Tacheng; these two ranges face each other across a semi-desert valley with low *Artemisia*, the habitat of *F. karelinii* (Fisch. ex D. Don) Baker. In late May 1989 we saw *F. yuminensis* growing wild under juniper, rose and *Ephedra* bushes among large rocks in peaty soil on the north side of a ridge at around 1400 m, but the splendid specimens cultivated by Duan were in sandy clay on the open hillside, growing alongside all the other species native to the area. Other species accompanying *F. yuminensis* in this locality are the splendid red *Paeonia hybrida* Pall., *Corydalis nobilis* Pers., the cowslip *Primula veris* L. subsp. *macrocalyx* (Bunge) Lüdi, purple dwarf *Iris scariosa* Willd. ex Link, *Glaucium squamigerum* Kar. & Kir. and *Chelidonium majus* L. var. *grandiflorum* Willd.

Duan and his wife Zheng Xiu-ju also collected and cultivated around five other *Fritillaria* species in their experimental farm in a remote mountain valley south of Xinjiang (Rix, 1991). They grow *F. pallidiflora* Schrenk ex Fisch. & C.A. Mey, and have described the closely-related *Fritillaria halabulana* X.Z. Duan & X.J. Zheng. They also found *Fritillaria meleagroides* Patr. ex Schult. f. near Tacheng, the first record for Xinjiang; this is one of the most widespread of all species of *Fritillaria*, found across Siberia and as far west as Bulgaria, growing in boggy places. Their other discoveries were the new species *F. yuminensis* (illustrated here), *F. albidiflora* and *F. tortifolia* (mentioned above) and they cultivated these five in large quantities in fields on



Fig. 1. Habitat of *Fritillaria yuminesis* (among dark rocks) and *Fritillaria tortifolia* (in scrub on grassy slopes) near Yumin, Xinjiang. Photograph: Martyn Rix.

their farm. On our visit in late May 1989 it was interesting to note different insects visiting the flowers: small solitary bees on *F. yuminensis* and *F. albidiflora*, bumble bees on the large flowers of *F. tortifolia* and blow flies on the black flowers of *F. meleagroides*. Most of the species were grown in separate but adjacent fields, and although there was some mixing of species, no obvious hybrids were seen.

THE USE AND CONSERVATION OF *FRTLILARIA*, BEL MU, IN CHINA

The Chinese Medicinal Plants Authentication and Conservation Centre (CMPACC) at the Royal Botanic Gardens, Kew was set up in 1998 as a joint initiative with the Institute of Medicinal Plant Development, Beijing. It has created a scientific reference and advisory centre for Chinese herbal medicines traded internationally in the interests both of patient safety in the West and to promote sustainable sourcing of the species used.

Part of the work of the Centre in 2006 involved obtaining authentic and vouchered samples of the rapidly declining *F. cirrhosa*, bulbs of which are the preferred source of the hugely popular medicine 'Chuan bei mu' used for treating coughs and asthma. Staff from the Centre visited a major *Fritillaria* 'natural fostering' project in the Ganzi district of Sichuan on the Tibetan plateau at c. 4000 m. Since commercial cultivation of this species has not yet proven successful, a major re-introduction programme of *F. cirrhosa* bulbs has been underway for the last 15–20 years in an attempt to re-populate the natural habitat of the species. This comprises low-growing alpine scrub dominated by dwarf species of *Salix*, *Sabina*, *Sibiraea* or *Rhododendron*. Using bulbs grown in the nearby nursery from wild-collected seed, some ten thousand hectares of this habitat have been set aside for this natural fostering work and the potential to establish a sustainable harvesting programme in coming years looks promising. The same project has also been studying other *Fritillaria* species (notably *F. taipensis* P.Y. Li, *F. pallidiflora*, *Fritillaria usuriensis* Maxim., *Fritillaria crassicaulis* S.C. Chen (syn. *Fritillaria wabuensis* S.Y.Tang & S.C.Yueh) and *Fritillaria sichuanica* S.C. Chen (syn. *Fritillaria mellea* S.Y.Tang & S.C.Yueh), which may be used as alternative sources of Chuan Bei Mu, based on levels of certain alkaloids present in their bulbs. It is hoped that such exciting initiatives can help to satisfy the huge annual demand

of Chuan Bei Mu, of which manufactured products are worth some US\$ 400 million annually (2002–2003 figures) such that the wild populations of the species involved can be effectively conserved.

Other conservation initiatives include those by Duan and Zheng who established their farm at Yumin, ‘the experiment station of fritillaries’, for the cultivation of *Fritillaria* for seed, to supply local farmers who grow the bulbs for medicine. A secondary purpose was to lessen the pressure on the species in the wild, which are (or were until local laws were introduced to protect them) exploited ruthlessly in Xinjiang as well as everywhere else in China. In this part of Xinjiang the species most often cultivated is *F. pallidiflora* yi beimu, which is found wild in alpine meadows and *Juniperus* scrub in the Dzungarskij Ala Tau, and neighbouring mountains south of Alma Ata, in both China, Kyrgistan and eastern Kazakhstan. In village gardens around Xining the plants are grown in raised beds with a ridge of earth around them, so that they can be irrigated in dry spring weather. Judging by the size of the plants, to around 60 cm tall, they must be well fertilised (Phillips & Foy, 1990).



Fig. 2. One of the experimental ‘natural fostering’ stations, where *Fritillaria cirrhosa* has been re-introduced to the wild, showing habitat and local field station, at c. 4000 m on the Tibetan plateau, west of Kangding, Sichuan. Photograph: Chris Leon.

A recent paper by Xiao Pei-Gen *et al.* (2007) describes the different groups of beimu, and the alkaloids found in their bulbs. Six main groups are recognized in this study. (1) Zhebeimu, mainly from cultivated *F. thunbergii*; (2) Yibeimu consisting of *F. walujewii* Regel and *F. pallidiflora* from Xinjiang; (3) Pingbeimu from *F. usuriensis* Maxim. cultivated in the north-east, in Heilongjiang, Jilin and Liaoning; (4) Chuanbeimu, derived mainly from *F. cirrhosa*, *F. przewalskii* Maxim. and *F. unibracteata* Hsiao & K.C. Hsia; the Qingbei, from these high-altitude species is the most sought-after variety. *F. delavayi* Franch. Lubei, is also included in the chuanbeimu group; (5) Hubei beimu from cultivated *F. hupehensis*, closely related to *F. monantha* Migo, and cultivated mainly in Hubei; (6) Anhui beimu, from *F. anhuiensis* S.C. Chen & S.F. Yin. These are primarily geographical groupings.

CULTIVATION. At Kew, the conditions suitable for most cold-climate species of *Fritillaria* suit *F. yuminensis*. It is worth remembering that the spring in central Asia comes quickly, and is warm and dry, typical of continental areas and in stark contrast to the wet and intermittent spring of maritime northwestern Europe, which can cause the stems to emerge as early as February. The bulbs should be kept as cool as possible until the stems begin to elongate, and then kept warm and well watered until flowering is over; after flowering keep rather drier until the leaves go yellow.

Because root growth in these central Asian species starts in late summer, repotting should be done as soon as possible after the stems have died down. A well-drained, sandy, humus-rich soil seems to suit the bulbs in cultivation. This species was introduced to cultivation from Duan's bulbs through the Catch Flower Co. in Beijing in 1999, and it is a specimen from that stock which is illustrated here.

Fritillaria yuminensis X.Z. Duan, *Acta Phytotaxonomica Sinica* 19:257(1981), Type: Yumin; Duan 00012 (holotype PE, isotype K!).

Fritillaria yuminensis var. *albiflora* X.Z. Duan & X.J. Zheng, *Acta Phytotaxonomica Sinica* 27(4): 308 (1989). Type: Yumin, Dunalala, in clivo gramineo, alt. 1100 m, 10, 04. 1986. Duan 00279.

Fritillaria yuminensis var. *roseoflora* X.Z. Duan & X.J. Zheng, *Acta Phytotaxonomica Sinica* 27(4): 309 (1989). Type: Yumin, Halabula He, in clivo glareoso ad flumen, alt. 1150 m, 15. 04. 1986. Zheng 000111 (PE).

Fritillaria yuminensis var. *varians* Y.K. Yang & G.J. Lin, in *J. Wuhan Bot. Res.* 5(2): 129 (1987).



Fig. 3. Typical Traditional Chinese Patent Remedy containing 'Chuan Bei Mu', *Fritillaria cirrhosa* D. Don.

Fritillaria tachengensis X.Z. Duan & X.J. Zheng, *Acta Phytotaxonomica Sinica* 25(1):61(1987). Type: Tacheng, Tarbahatai Mount. Wulastai River, alt. 1700 m, May 5, 1984, X.Z. Duan 00101 (PE).

Fritillaria tachengensis var. *nivea* Y.K. Yang & S.X. Zhang, in J. Wuhan Bot. Res. 5(2): 129 (1987).

DESCRIPTION. *Bulb* to 3 cm across, without bulbils. *Stem* 30–50 cm, rarely to 60 cm, purplish. *Leaves* shining green, linear, the lowest opposite, to 2 cm broad, the lower in whorls of 3 to 5, 5–8 cm long, the upper alternate below the flowers, the bract leaves paired or in a whorl of 3, 2–4 mm wide, the uppermost and bract leaves coiled at their apex. *Flowers* 1–20, broadly conic, with a right angle at the angle of the bell, outside and inside, white, pink, or lilac to dark blue(!), without tessellations, with scent like hyacinths. *Tepals* 1.5–2.3 cm long, the inner 1.5 cm wide, the outer narrower, oblong or ovate-oblong. *Nectary* lanceolate, small and insignificant, at base of tepal, with a smooth green area on either side, the nectaries on the outer tepals larger than those on the inner. *Filaments*, slender, smooth; pollen yellow. *Style* 8–15 mm, narrowly clavate, completely unlobed or with lobes up to 1 mm, smooth. *Capsule* cylindrical, winged.

DISTRIBUTION. North-west China, Xinjiang, Yumin and Tacheng.

HABITAT. Growing on forest margins, in scrub and grassy places, and on open gravelly slopes at around 1100–2800 m.

FLOWERING TIME. April to May.

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