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How many species are there in the genus *Tripterygium* Hook. f. (Celastraceae)?

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***Keywords*:** fruits, inflorescences, lectotypification, morphology, taxonomy.

Summary. *Tripterygium* Hook. f. is a small East Asian genus in the family Celastraceae, well known as an ornamental plant and for its use in traditional Chinese medicine. Over the years, the genus scope and interpretation of diagnostic characters have varied depending on the understanding of the species concept. This explains the inconsistency in the total number of species among various authors. In total, the list of accepted taxa ranges from one to eight items (*T. bullockii*, *T. doianum*, *T. hypoglaucum*, *T. forrestii*, *T. regelii*, *T. regelii* var. *occidentale*, *T. wilfordii*, *T. wilfordii* var. *exesum*). A recent study by Xu et al. (2024), based on complete chloroplast genomes sequencing, prompted a re-evaluation of the genus. After critically examining all available materials, including personal study of herbarium specimens of European and Asian collections, and emphasizing morphological characters, we conclude that the genus comprises three to four species, depending on the species concept applied. Special attention is focused on clear, qualitative and stable features of fruits morphology, their morphometric parameters and fruit shape: 1) fruit shape in relation to its central axis; 2) relation of a size of the fruit body to general fruit length; 3) width of winged appendages in relation to fruit central axis; 4) size of persisting stile on the fruit apex. Inflorescence morphology is used as an additional character. Lectotype of *T. regelii* is designated here. A key for the identification of all four species is provided, and data on their geographical distribution are given.

Сколько же видов в роде *Tripterygium* Hook. f. (Celastraceae)?

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Ключевые слова: лектотипификация, морфология, плоды, соцветия, таксономия.

Аннотация. *Tripterygium* Hook. f. – небольшой восточноазиатский род семейства Celastraceae, хорошо известный в качестве декоративного растения, а также использованием в традиционной китайской медицине. В течение многих лет объём рода и трактовка диагностических признаков менялись в зависимости от понимания концепции вида. Отсюда – и разнобой в понимании общего числа видов теми или иными авторами. Таксономическое разнообразие рода в зависимости от точки зрения авторов варьирует от одного вида до шести видов и двух разновидностей (*T. bullockii*, *T. doianum*, *T. hypoglaucum*, *T. forrestii*, *T. regelii*, *T. regelii* var. *occidentale*, *T. wilfordii*, *T. wilfordii* var. *exesum*). Недавнее исследование Xu et al. (2024), основанное на полном

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секвенировании геномов хлоропластов, побуждает к переоценке объёма рода. После критического изучения всех имеющихся материалов, включая персональное исследование гербарных образцов из основных европейских и азиатских коллекций, и с особым вниманием к морфологическим признакам, автор пришёл к заключению, что род включает от трёх до четырёх видов, в зависимости от принимаемой концепции вида. Главное внимание уделено чётким, качественным и устойчивым признакам морфологии плодов, их форме и морфометрии: 1) форма плода относительно его центральной оси; 2) соотношение размера тела плода к общей его длине; 3) ширина крыловидных выростов относительно центральной оси плода; 4) размер сохраняющегося столбика на верхушке плода. В качестве дополнительных признаков использованы особенности структуры соцветий. Проведена лектотипификация названия *T. regelii*. Предложен ключ для определения всех четырёх видов, приведены данные об их географическом распространении.

Introduction

Representatives of the East Asian genus *Tripterygium* Hook. f. (Tripterygium…, 2026a) are very popular plants in decorative gardening and landscaping in many countries; they are also used in traditional Chinese medicine due to having unique pharmacological effects and complex chemical composition (Lv et al., 2019). Because of the poor understanding of the genus circumscription, the exact number of accepted species within the genus remains uncertain.

The genus *Tripterygium* (Celastraceae) was firstly described by J. Hooker in 1862 based on specimens, collected by Wilford on the Taiwan Island (Formosa) in 1858 with only one species, *T. wilfordii* Hook. f. In the 1860s, E. L. Regel (St. Petersburg Botanical Garden) cultivated plants from seeds collection on Kyushu Island, Japan, and reported them as *T. wilfordii* (Regel, 1869); these specimens, however, represent a different species. Later, Hemsley (Forbes, Hemsley, 1886) reported the first find of the genus from Korea (as *T. wilfordii*). Leveille (1911) described *Aspidopterys hypoglauca* H. Lev. (Malpighiaceae) collected by J. Cavalerie in Guizhou (China), which Hutchinson (1917) transferred into the Celastraceae as *T. hypoglaucum* (H. Lev.) Hutch. In 1912, Takeda together with Sprague studied specimens in Kew and British Museum herbaria and opened one more species, *T. regelii* Sprague et Takeda, from Japan and Korea, which corresponds to Regel's specimens from St. Petersburg and therefore were named by them in honor of Eduard August von Regel (1815–1892). In 1932, German botanist Loesener accepted three species in the genus: *T. hypoglaucum* (= *T. forrestii* Loes.) from Yunnan, Hunan and Zhejiang; *T. regelii* from Japan, Korea and NE China; *T. wilfordii* Hook. f. (= *T. bullockii* Hance, *T. wilfordii* var. *bullockii* (Hance) Matsuda) from Taiwan, Hunan and Zhejiang. The treatment of the genus by Loesener (1932) can be regarded as the first comprehensive revision, and it has been followed by most subsequent East Asian researchers[1], including the well-known specialist of the Celastraceae family, Hou (1950). The Japanese botanist Jisaburo Ohwi described one more species (fourth), *T. doianum* Ohwi, from S Kyushu and Yakushima (endemic) in 1932 (Ohwi, 1932), which was accepted by K. Zoku in Ohwi's "Flora of Japan" (Zoku, 1965). In the new "Flora of Japan" (eds. K. Iwatsuki et al.: Noshiro, 1999; IPNI. URL: https://www.ipni.org/p/14728-2), no new taxonomic treatments or nomenclatural combinations were made, and the emphasis in defining species was shifted from leaves and fruits characters to flowers and inflorescences.

Various regional reports on the flora published many years later usually follow traditional concept of the genus proposed by Loesener in 1932 with addition by Ohwi (e. g., Zoku, 1984; Ka, 2006).

Ma et al. (1999) conducted a revision of the genus, examining key morphological characters, namely: 1) white powder on lower leaf surface, 2) pubescence of branches, 3) leaves, their sizes and shape, and 4) inflorescences, their sizes and shape, to characterize the extent of variation in the genus. Furthermore, Ma et al. (1999) emphasized that variation in fruit colour and shape, particularly at the base and apex, is influenced by the degree of maturation, as well as the type of habitat and resources available to the plant. However, they recognized only a single, widely distributed and polymorphic species, *T. wilfordii*, within the genus (also in: Ma, Funston, 2008). The evidence presented by these authors in favor of recognizing only one polymorphic species is clearly biased, and all the arguments they use are interpreted in favor of one from the competing hypotheses, which do not allow their conclusions to be assessed unambiguously. In fact, individual populations of the genus in nature are separated from each other

[1] Wang Chen-Hwa (1936) in his "The studies of Chinese Celastraceae" considered *T. hypoglaucum* and *T. forrestii* as separate species (based on their differences in leaf characters), and the latter species as most allied to *T. wilfordii*.

by significant spaces (there is a disjunction of the range), and the pattern of variability manifests itself differently in different parts of the range. Particularly striking are the differences between island and mainland populations, on the one hand, and between northern (Northeastern China, Japan, the Korean Peninsula) and southern (Taiwan and the southern provinces of China) populations, on the other. In my opinion, variability pattern observed in different parts of the range in natural populations of *Tripterygium* is of a rather complex nature (probably, different geographic races) in the understanding of Prof. A. K. Skvortsov (Skvortsov, 2005) and can hardly be described within the framework of recognition of the only polymorphic species *T. wilfordii*.

Short time after the publication by Ma et al. (1999), researchers conducted expert assessment of the complex characters of the molecular phylogenetic data – and came to the conclusion that there are still more species in the genus, two or even three (Liu et al., 2007; Law et al., 2011; Mu et al., 2012; Ma et al., 2017).

Tripterygium wilfordii was recently reported from Northern Vietnam, Phia Oac-Phia Den National Park: 22°37′32.0″N, 105°52′52.4″E (Hai et al., 2021). Hundley and Chit Ko Ko (1961) reported the presence of *T. wilfordii* from Myanmar (Burma) which rises serious doubt as this phytogeographical range known to be the distributional range of *T. hypoglaucum*[2]. The species occurring in Japan, namely *T. doianum* and *T. regelii*, share several overlapping characters, making their separation challenging (Ma et al., 1999). This raises questions regarding their taxonomic status, specifically whether they should be treated as distinct species or as form / subspecies of a single species. Details of geographical distribution of typical *T. regelii* (two varieties) and *T. doianum* in Korea and Japan are given by T. Yamazaki (1993).

Recently, a new article was published by Xu et al. (2024), in which the results of the complete chloroplast genomes sequencing (15 chloroplast genomes) of representatives of the genus *Tripterygium* were reported. Based on phylogeny, the latter authors proved the monophyly of *T. hypoglaucum* and the potential sister relationship between *T. wilfordii* and *T. regelii.*

Materials and Methods

All available herbarium materials were critically studied, including personal author's work in main European and Asian herbaria (CDBI, E, IBSC, K, KUN, LE, MW, MHA, PE). Also scan and digital type specimens for all described species were studied; phenological investigation are conducted and rhythms of seasonal development are studied for *T. regelii*, which is cultivated in collections of the Dendrological garden named after R. I. Schroeder (Moscow, Russia), Tsitsin Main Botanical Garden, RAS (Moscow, Russia), and also in the Botanical Garden-Institute of the Far East Branch of RAS (Vladivostok, Russia). Additionally, herbarium materials of *T. regelii* were collected in mountain region of Democratic People's Republic of Korea in July 2026 (Prov. Ryanggang, Samjiyon). To clarify the number of fruit morphological characters, the comparative-carpological studies of three species of *Tripterygium* – *T. hypoglaucum*, *T. regelii* and *T. wilfordii* – were conducted. All current materials from the platform "Global Biodiversity Information Facility" (GBIF) were used (Tripterygium…, 2026b). Additionally, the database of the KAG Herbarium (Tagane, 2024) was used.

Digital images of type herbarium specimens were examined on the "JSTOR. Global Plants" resource: (Tripterygium forrestii, 2026; Tripterygium hypoglaucum, 2026; Tripterygium regelii, 2026; Tripterygium wilfordii, 2026).

When choosing a lectotype here in *T. regelii* the author followed the recommendations to give priority to the authentic material kept in LE, with original determinations and notes by C. J. Maximowicz, because duplicates were sent by him to the main European and American Herbaria (Grabovskaya-Borodina, 2016).

Results

Carpological studies

The fruit of *Tripterygium* is described usually as the samara with three lateral wings (Loesener, 1942; Ma et al., 1999; Simmons, 2004). Here, the fruit of *Tripterygium* is accepted as three-winged unilocular and one-seeded pyrenarium, because pyrene (bone) is pronounced in endocarp – the mechanical strand, formed by macrosclereids (Savinov, Solomonova, 2017).

Here, only a brief mention of the fruit structure is provided along with the citation. For a detailed understanding, readers can refer to another article (Savinov, Solomonova, 2017). Three studied species are well different from each other by fruit morphology and also details of anatomical structure of pericarp and spermoderm, namely total number of cell

[2] The author has not seen any specimens of *Tripterygium* from Myanmar during this study.

layers, relative thickness of parenchymal and sclerenchymal parts of pericarp.

Special attention was spared to the steadily contrast, well-identifiable (demarcated) characters, such as morphometric signs and fruit shape: 1) fruit shape in relation to its central axis; 2) relation of the size of the fruit body to the general fruit length; 3) width of winged appendages in relation to the fruit central axis; 4) size of persisting stile on the fruit apex (Fig. 1).

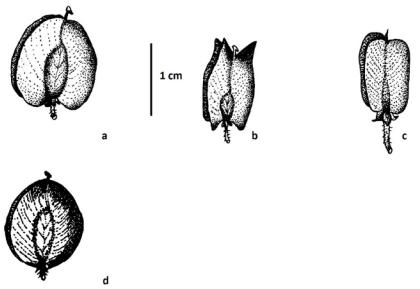


Fig. 1. Fruit morphology of the four species of *Tripterygium*: a – *T. regelii*; b – *T. hypoglaucum*; c – *T. wilfordii*; d – *T. doianum* (orig., schematized).

Taxonomic treatment

Tripterygium Hook. f. 1862, in Benth. et Hook. f., Gen. Pl. 1: 368.

Type: *T. wilfordii* Hook. f. Eastern Asia, 3 or 4 species, with certain geographic disjunction.

Deciduous woody liana (scandent shrubs), glabrous or tomentose. Leaves alternate, serrate. Inflorescences terminal, and also axillary, thyrsoid (in axils of usual upper leaves at terminal thyrse – dichasial). Closed terminal thyrses completely dead after fruiting. Flowers bisexual or unisexual (polygamous), 5-merous, disk fleshy, margins upturned, 5-lobed, intrastaminal; anthers longitudinally dehiscent, introrse; ovary 3-locular; ovules anatropous (erect), 2 per locule. Fruit ("samara"; winged pyrenarium in this study) with 3 lateral wings, chartaceous; seed 1, without aril, trigonous, albuminous. $2n = 24$.

Tripterygium doianum Ohwi, 1932, Acta Phytotax. Geobot. 1: 140.

≡ *Tripterygium regelii* var. *doianum* (Ohwi) Masam., 1934, Mem. Fac. Sci. Taihoku Imp. Univ. 11: 280.

Holotype: [Japan] "Kiushiu, Mt. Takakuma, Ohsumi, Yoshio DOI s. n. 4 VIII 1928" (KYO! [KYO 00106663]) (Fig. 2).

Distribution: Japan (S Kushu (Kiushiu), Yakushima, Ryukyu).

T. hypoglaucum (H. Lev.) Hutch., 1917, Bull. Misc. Inform. Kew 1917: 101.

≡ *Aspidopterys hypoglauca* H. Lev., 1911, Fedde Repert. Spec. Nov. Regni Veg. 9: 458.

Holotype: [China] "Kouy-Tcheou (Guizhou), Ma-Jo, J. Cavalerie no. 3316" (E!; iso – L).

= *T. forrestii* Loes., 1913, Notes Roy. Bot. Gard. Edinburgh 8: 4, t. 2.

Syntypes: "China, Yunnan, G. Forrest 4290" (E [E00275532!], BM, S.

Distribution: China (Yunnan, Sichuan, Guizhou, Hunan, Zhejiang).

T. regelii Sprague et Takeda, 1912, Bull. Misc. Inform. 1912: 223.

≡ *T. wilfordii* var. *regelii* (Sprague et Takeda) Makino, 1940, 111. Fl. Nipp. 360, t. 1079.

Lectotype (designated here): [Japan] "Nagasaki, Kunjusan, Maximowicz. October 1863" (LE 01070465 [Fig. 3]; iso – LE [LE 01070461–LE01070464 !!], BM, K, etc.; syn – LE: "Corea, V. Komarov, 1897" [LE 01004861, LE 01004863 !!]; BM, K, etc.; "Hondôji, prov. Uzen, R. Yatabe, 1887" (?), "Mt. Chokai, prov. Ugo, M. Komai, 1906" (?); "Corea, Seoul, Carles, 1884" (?) (K, BM, etc.); "Gassan (Hondoji), Yamagata Pref., R. Yatabe, Jul. 1887" (K, TI).

Note. The latter gathering was cited as lectotype by Yamazaki (1993: 365). However, since both herbaria (K and TI) were mentioned, we treat that designation as invalid.

= *T. regelii* var. *occidentale* T. Yamazaki, 1993, J. Jap. Bot. 68, 6: 365.

Type: "Korea, Seoul, Pukanshan, T. Uchiyama, Oct. 14. 1900, s. n." (TI).

Distribution: Japan, Korea, NE China. A report of the species by Kim (2015) for Russia (Amur) is obviously erroneous (Fig. 4).

Nomenclatural and historical notes. Both E. Regel (1869) and C. J. Maximowicz (1881) were dealing with *T. regelii*, though they have identified relevant material as *T. wilfordii*. Furthermore, Regel's definition was confirmed by Hooker himself, as evidenced by the herbarium specimen sent by Regel and collected from a plant grown in the St. Petersburg Botanical Garden (the seeds were collected in Kyushu). Maximowicz cited own collection form Kyushu (it is not cited in the protologue of *T. regelii* – Takeda, 1912), Savatier's collection (also absent in the protologue), as well as a mention that the species grows in



Fig. 2. Holotype of *Tripterygium doianum* (KYO 00106663).



Fig. 3. Lectotype of *Tripterygium regelii* (LE 01070465).



Fig. 4. Plant habit of *Tripterygium regelii* (a – flowers and developing fruits; b, c – young fruits) in mountain region of Democratic People's Republic of Korea (orig., July 2026).

the St. Petersburg Botanical Garden. In the protologue of *T. regelii* (Takeda, 1912), material by Maximowicz from Higosan (LE 01070466, LE 01070468) is not cited.

T. wilfordii Hook. f. in Benth. et Hook. f., 1862, Gen. Pl. 1: 368.

Lectotype (or possibly holotype) (designated by Turner, 2016): [Taiwan] "NW Formosa, near W side of Formosa; River Sanar «Insula Formosa Incola», June 1858, C. Wilford #484" (K [2 sheets] [K000478771!, K000478770!], images online; iso – E!).

= *T. wilfordii* var. *bullockii* (Hance) Matsuda, 1910, Bot. Mag. Tokyo. 24: 286.

≡ *T. bullockii* Hance, 1878, J. Bot. 259 (1880), Bullock Herb, propor. n. 20692 [BM000838816!] image online.

= *T. wilfordii* var. *exesum* Sprague et Takeda, 1912, Bull. Misc. Inform.: 222.

Type: "China, Yunnan, Mengze (Mengzhi), N. Mts., alt. 1520m, A. Henry 10203" (?).

Distribution: Taiwan, China (Yunnan, Guangxi, Guangdong, Hunan, Hubei, Jiangxi, Anhui, Fujian, Zhejiang), N Vietnam.

Notes. Both sheets (K000478770, K000478771) were used by Hooker f. to describe the genus *Tripterygium* (Gen. Pl. 1(1): 368. 1862). Illustration attached by him in the protologue is associated with K000478770.

Key for identification of species of the genus *Tripterygium*

1. Main terminal inflorescence is well isolated from vegetative shoots, with serial buds from which paracladia develop. Fruit ovate or oval, with broad or narrow wings 2

+ Main terminal inflorescence is weakly isolated from vegetative shoots, with transitional leaves and bracts. Fruit oval, elongated along its central axis, wings narrow, usually rounded at the apex. The body of fruit occupies 1/3 of its length. The column at the top is very short ..... *T. wilfordii*

2. Fruit ovate, with broad wings (0.6 mm each). The body of fruit is almost equal to length of entire fruit. The column is long 3

+ Fruit oval, elongated along its central axis, with narrow wings, truncated at the apex. The body of fruit is small, equal to approximately 1/4 of its entire length. The column at the top is very short .... *T. hypoglaucum*

3(2). Fruit with cordate base ..... *T. regelii*

+ Fruit with rounded or truncate base ....*T. doianum*

Discussion

Since the description of the genus *Tripterygium* by J. Hooker (Bentham, Hooker, 1862), views on its limits and the number of species have changed repeatedly, often cardinally, among different authors. This can be confirmed by comparing the classic treatment by Loesener (1932) and the relatively recent revision by Ma et al. (1999). At the same time, researchers could not ignore both the extensive geographic range of the genus and the significant polymorphism of traits, as well as the particular pattern of variability that appears in different parts of its range. Increased interest in this plant in recent years from traditional Chinese medicine and the

presence of a number of important biologically active substances in its organs has contributed to a reconsideration of established views. This is how the idea arose that the genus is not monotypic, but that several independent species, most often two or three, should be distinguished within it (Liu et al., 2007; Law et al., 2011; Mu et al., 2012; Ma et al., 2017). In a series of above cited recent publications, three species are grouped by certain characters so that one is opposed to the others (molecular phylogeny + geography – *T. hypoglaucum* vs. *T. wilfordii* + *T. regelii*; inflorescences – *T. regelii* + *T. hypoglaucum* vs. *T. wilfordii*; fruits and RAPD-analysis + phylogeographic and phylogenetic analysis – *T. regelii* vs. *T. hypoglaucum* + *T. wilfordii*).

Thus, over the past 25 years, new data have accumulated indicating the need to distinguish several species in the genus *Tripterygium*. This is evidenced by critical study of all available herbarium materials from different points of the range, an analysis of the pattern of variability, a comparative morphological study of inflorescences and fruits (this study), as well as the latest results of complete chloroplast genomes sequencing (Xu et al., 2024). The latter authors have assembled 12 chloroplast genomes of *Tripterygium*, presented their comparison to reveal the interspecific difference and intraspecific variation and came to the conclusion that *T. hypoglaucum* is monophyletic and could be distinguished from *T. wilfordii*, whereas *T. wilfordii* was nested within *T. regelii*. The result in other study with combined nuclear and plastid DNA markers analysis (Mu et al., 2017) suggests that *Tripterygium* constitutes a natural monophyletic clade within *Celastrus* with strong support value, and sister position between *T. wilfordii* and *T. regelii*. These conclusions based on the molecular data completed support by our critical morphological and taxonomical studies. As a result, basic diagnostic characters for all four accepted here species of *Tripterygium* are summarized (Table 1).

The varieties described by various authors within certain species of *Tripterygium* (in particular, *T. regelii* var. *occidentale*, *T. wilfordii* var. *exesum*)

Table 1. Morphological characters and distribution four species of the genus *Tripterygium*

Species / Characters	***T. doianum***	***T. hypoglaucum***	***T. regelii***	***T. wilfordii***
Leaves	5–10 cm	9–10 cm	5–15 cm	7–9 cm
Inflorescences and panicles	Main terminal inflorescence is well isolated from vegetative shoots, with serial buds from which paracladia develop, panicles glabrous	Main terminal inflorescence is well isolated from vegetative shoots, with serial buds from which paracladia develop, panicles glabrous	Main terminal inflorescence is well isolated from vegetative shoots, with serial buds from which paracladia develop, panicles puberulous	Main terminal inflorescence is weakly isolated from vegetative shoots, with transitional leaves and bracts, panicles puberulous
Flowers	4–5 mm across	7–9 mm	5–6 mm across	Up to 7 mm across
Fruits	Ovate, with broad wings (0.6 mm each). The body of fruit is almost equal to length of entire fruit. The column is long, with rounded or truncate base	Oval, elongated along its central axis, with narrow wings, truncated at the apex. The body of fruit is small, equal to approximately one fourth of its entire length. The column at the top is very short	Ovate, with broad wings (0,6 mm each). The body of fruit is almost equal to length of entire fruit. The column is long, with cordate base	Oval, elongated along its central axis, wings are narrow, usually rounded at the apex. The body of fruit occupies 1/3 of its length. The column at the top is very short
Distribution	Southern Japan (S. Kyushu, Yakushima, Ryukyu)	Myanmar ?, China (Yunnan, Sichuan, Guizhou, Hunan, Zhejiang)	Northeastern China, Korea, Japan	Taiwan, southeastern provinces of China, North Vietnam

are not discussed here, as the author follows the approach of A. K. Skvortsov (2005) and does not recognize infraspecific categories. It should be noted that these categories are not considered in molecular studies also.

Conclusion

All four species studied – *T. doianum*, *T. hypoglaucum*, *T. regelii*, *T. wilfordii*, are different from each other very well by inflorescence structure and fruit morphology. This conclusion basically correlates with molecular phylogenetic data.

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