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Subject: Tripterygium and Potential Sources of Triptolide

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TAXONOMY

The genus, Tripterygium (Celastraceae), originates from a specimen collected by Wilford from Formosa in 1858 and was described by Hooker in 1862 - Tripterygium wilfordii (Benth. & Hook., Genera Pl., I, pg. 368).

About 13 combinations of species, varieties and forms have been described in the genus, Tripterygium. All names described have a synonymous relationship with the type species (T. wilfordii). Based on nomenclature, recognition might be given to one to five species. Loesener (1931, 1942) and Lin (1932) recognized three species: T. wilfordii, T. regelii, and T. hypoglaucum. Loesener also had described earlier another species T. forrestii, but in his treatment of Tripterygium in 1931 he sunk T. forrestii under T. hypoglaucum. Other references appear to have erroneously cited T. forrestii as a synonym of T. wilfordii*.

Another possible species is T. doianum described by J. Ohwi in 1932. This species was later reduced to a variety of T. regelii by Masmune; however, Ohwi still maintains T. doianum as a distinct species in the Flora of Japan, 1965.

Based on Loesener, Lin, and Ohwi (Flora of Japan) there would seem to be either three or four species of Tripterygium: T. wilfordii, T. hypoglaucum, T. regelii and possibly T. doianum. Whoever assembled the literature on Tripterygium for our file indicated that there are four species but listed T. forrestii (synonym of T. hypoglaucum) and not T. doianum.

* The literature in the POSI File on Tripterygium appears to be very extensive. T. forrestii and T. hypoglaucum are cited as synonyms in Chittenden, F. J., 1965, Dictionary of Gardening (RHS), Vol. 4, pg. 2149-50 and in Steward, A., 1958, Manual of Vascular Plants of the Lower Yangtze Valley, China, pg. 224 (T. forrestii only). I cannot find any taxonomic references for the reduction of T. hypoglaucum under T. wilfordii. If this were the case, only two species of Tripterygium would be recognized: T. regelii (Japan & Korea) and T. wilfordii (China, Taiwan, & Burma).

Translations of three references would be helpful to understanding the taxonomic relationships and cultivation of species of Tripterygium. These are: 1) Loesener, T., 1931, "Uber die gattung Tripterygium" in Ber. Deut. Bot. Ges. 50a, pp. 5-14 (in German); 2) Lin, Hsuing-hsiang, 1932, A study of Genus Tripterygium, J. Agric. Assoc. China 100: 48-73 (in Chinese); 3) Golovac, A. G., 1967, The liana Tripterygium - a new promising plant for landscape planting, Moscow G. Bot. Sad. Byul. 65: 53-57 (in Russian).

DISTRIBUTION AND ECOLOGY

Species of Tripterygium appear to have a spotty distribution occurring in Japan, Korea, China, Taiwan and Burma. Without actually revising this genus the distribution of those species that occur in China cannot be described accurately. The following descriptions are generalizations on three species which were assembled from the literature and herbarium data in our files.

Tripterygium regelii: Japan and Korea: common along roadsides, ditches; in open meadows, woodlands and thickets; at elevations from sea level to 5,000 ft.

T. wilfordii: Taiwan and eastern China: thickets and river banks, 300-2,400 ft. Reported to be cultivated rather widely in several Chinese provinces on the south side of the Yangtze River, especially in Chekiang Province (but this may be T. hypoglaucum).

T. hypoglaucum: China (Burma?): moist banks; river drainage basins; dry open thickets and scrubby slopes; meadows; shaded woodlands; at elevations from 2,700-12,000 ft.

INTRODUCTIONS AND CULTIVATION

Species of Tripterygium were introduced in the United States under the names of T. regelii and T. wilfordii var. exesum. T. wilfordii var. exesum is regarded as a synonym of T. hypoglaucum by Loesener (1931) and Lin (1932). The origin of the cuttings planted at Glenn Dale, Maryland, in 1939 is from the Chekiang Province of southern China and Loesener has determined specimens from this area as T. hypoglaucum. Also, most or all of the literature dealing with the chemical investigations of Tripterygium (particulary the studies on insecticidal properties) appear to be actually with T. hypoglaucum instead of T. wilfordii and T. forrestii under which these references usually appear.

Both T. hypoglaucum and T. regelii are easily cultivated from seed, cuttings or suckers. Indications are that T. regelii is a more hardy plant than T. hypoglaucum, and T. hypoglaucum prefers warmer climates. Species of Tripterygium are commonly cultivated in the Chekiang Province, south of the Yangtze River.

Several thousand cuttings of T. hypoglaucum were planted at Glenn Dale in early 1942 to increase the stock of Tripterygium (for insecticidal purposes) and to evaluate the yield of roots (dry-weight) grown in infertile soil and to application of fertilizers.

At the end of two growing seasons the application of fertilizers gave an average of 31% greater yield (777 pounds compared to 1,127 pounds per acre). The variation in the yield from treatment with fertilizer was 365 to 2,286 pounds per acre (dry weight of roots).

From Glenn Dale, Maryland, cuttings of Tripterygium were sent to other areas in the U.S. for propagation (Statesville and Chapel Hill, North Carolina; Knoxville, Tennessee; Auburn, Alabama; College Station, Winter Haven, Brownwood and Chillicothe, Texas). Very little success was achieved in planting and various excuses were cited for their failure. However, in reading the details, most of the failure might be attributed to lack of care or interest because most of the cuttings were dead before being rooted.

Tripterygium regelii was grown from seed at the Arnold Arboretum in 1940. The seeds were collected by J. C. Jack in 1905 near Seoul, Korea. T. regelii grows well and is easily propagated from seeds, cuttings or suckers. Planted against a trellis, wall, post or tree, it makes rampant growth and flowers profusely in July. By pruning, it can be grown as a bush in the same manner as the Climbing Hydrangea (Hydrangea petiolaris). This species also was cultivated at the Arboretum of Barnes Foundation, Merion, Pennsylvania in 1968.

SAMPLES FOR SCREENING, FRACTIONATION AND ISOLATION OF THE ACTIVE AGENTS

Unfortunately, no herbarium specimens are filed in this Laboratory to represent samples of Tripterygium supplied for anticancer screening or fractionation and isolation of triptolide. Samples have been accessioned under ten PR-numbers (21,474; 21,476; 27,220-27,222; 27,783; 28,340; 28,341; 33,364; 35,491). We have reference samples for five of these (27,220-27,222; 27,783; 35,491) and all appear to be similar. PR-numbers 27,783 (3 pounds) and 33,364 (190 pounds) were supplied from Hong Kong and the remainder were sent to us from Taiwan.

Since there are no herbarium specimens on file, the identification of species of Tripterygium remains in doubt. Presumably, the initial activity originated from the same plant material grown at Glenn Dale; thus, B-99943 is probably T. hypoglaucum and not T. wilfordii. Recollections from Taiwan are probably T. wilfordii, and those from Hong Kong can not be determined. An extract of T. regelii (from Pennsylvania?) was submitted for testing in 1959 and no activity was reported.

POTENTIAL SOURCES OF TRIPTOLIDE

The isolation of triptolide was made from large samples of Tripterygium supplied from Taiwan. Since the only species of Tripterygium in Taiwan is T. wilfordii, we can assume that triptolide was identified from T. wilfordii. T. regelii is regarded as a very close relative of T. wilfordii and should be considered as a possible source even though one extract from this species showed no activity. Samples supplied from Hong Kong were inactive which could be either T. wilfordii or T. hypoglaucum, and T. hypoglaucum has to be considered as a potential source because the initial activity may have been from this species.

For the immediate future, our supplier in Taiwan remains the likely source of obtaining triptolide. If plants of T. wilfordii are not available in quantity, then efforts should be directed to cultivation of T. wilfordii using those plants of T. wilfordii from Taiwan.

Species in genera related to Tripterygium should be considered as potential sources of triptolide or other related compounds especially in view that generic concepts are poorly defined in the Celastraceae. The occurrence of maytansine in two closely related genera, Maytenus and Putterlickia, is a good example. Loesener classifies Tripterygium in the subfamily Tripterygiaides which include the genera Ptelidium (2 spp. - Madagascar), Zinowiewia (7 spp. - Mexico to Venezuela), Plenckia (4 spp. - S. America), and Wimmeria (12-14 spp. - central Mexico to Salvador). Ding Hou and Loesener recognized the genus, Wimmeria, as being very closely related to Tripterygium. Wimmeria microphylla is active with a high T/C value but the active agent has not yet been characterized.

Besides investigating phenetic relationships as suggested in the above examples, cladistic relationships might provide possible leads to sources of triptolide. For example, ansa macrolids also were isolated from Colubrina which is classified by Cronquist and others in another family (Rhamnaceae) of a related order (Rhamnales). The relationship of Colubrina to members of the Celastraceae might be much closer than it would superficially appear. Bentham and Hooker placed the Celastraceae and Rhamanaceae in the same order - Celastrales. Johnston (1971) regarded Colubrina as the most primitive genus of the family - Rhamanaceae. In the more primitive family, Celastraceae, the stamens are not alternate with the petals in all genera but can be opposite as in the Rhamanaceae (ex. Forsellesia). The fruits in some genera are similar in both Celastraceae and Rhamanaceae. The ancestral forms that gave rise to Colubrina and Maytenus may have led to others with ansa macrolids that are possibly classified in other families of the Disciflorae. Likewise, triptolide or related diterpenes might be present in other families. Exploring both phenetic and cladistic relationships might be useful to discover other sources of triptolide from plants.

POSSIBLE SPECIES OF TRIPTERYGIUM AND SYNONYMS

Two taxonomic studies were published on the genus, Tripterygium. Both studies appear to be independent and were published almost in the same year (1932). One is in German by Loesener (Uber die Gattung Tripterygium; Ber. Deut. Bot. Ges. 50a: 5-14, 1931) and the other in Chinese by Lin (A study of genus Tripterygium; J. Agric. Assoc. China 100: 48-73, 1932). With one exception, both taxonomists made the same interpretation of this genus. The first three species listed below are those recognized by Loesener and Lin.

1. Tripterygium hypoglaucum (Levl.) Hutchins in Kew Bull. 1917, 275.

   Aspidopteris hypoglauca Levl. in FEDDE, Repert. Vol. 9, 1911, 458.
   Tripterygium wilfordii Hook. f. var. exesum Sprague & Takeda in Kew Bull. 1912, 222.
   *T. forrestii Loes. in Notes Roy. Bot. Gard. Edinburgh Nr. 36, 1913, 4 u tab. II.

2. Tripterygium regelii Sprague & Takeda in Kew Bull. 1912, 223.

   T. wilfordii sensu auct. Japan, non Hook. f.
   T. wilfordii var. regelii (Sprague & Takeda) Makino in Ill. Fl. Nippon: 360 (1940)
   T. regelii var. hypoleucum Hayashi in Bull. Gov. For. Exp. Stat. no. 57, 156, photo (1952).
   T. regelii f. hypoleucum (Hayashi) Hara in Enumeratio spermatophytarum japonicum III: 94, 1954.

3. Tripterygium wilfordii Hook. f. in Bentham & Hooker, Gen. Pl. I, 368, 1862.

   T. bullockii Hance in Journ. Bot. 1880, 259.
   **T. wilfordii var. bullockii (Hance) Matsuda in Tokyo Bot. Mag. XXIV (1910), pg. 286.

4.(?) Tripterygium doianum Ohwi = T. regelii var. doianum (Ohwi) Masamune.

* Tripterygium forrestii and T. hypoglaucum are listed as synonyms of T. wilfordii by Chittenden, (1965) Dictionary of Gardening (R.H.S.), Vol. 4, pp. 2149-50. T. forrestii is cited as a synonym of T. wilfordii in Manual of Vascular Plants of the Lower Yangtze Valley, China; p. 224 (Steward, 1958). Also a few references on insecticidal properties and chemistry of Tripterygium mention that T. forrestii = T. wilfordii and one cites Tripterygium exesum (unpublished combination?)

** This name and reference is cited under Tripterygium wilfordii in Loesener but under T. regelii in Lin.

LIST OF NAMES FOR SPECIES, VARIETIES AND FORMS DESCRIBED IN THE GENUS TRIPTERYGIUM

Tripterygium bullockii Hance
T. doianum Ohwi
T. forrestii Loes.
T. hypoglaucum (Levl.) Hutchins.
T. regelii Sprague & Takeda
T. regelii var. doianum (Ohwi) Masamune
T. regelii var. hypoleucum Hayashi
T. regelii forma hypoleucum (Hayashi) Hara
T. wilfordii Hook. f.
T. wilfordii var. bullockii (Hance) Matsuda
T. wilfordii var. exesum Sprague & Takeda
T. wilfordii var. regelii (Sprague & Takeda) Makino

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Kinman, Murray. 1950, 1952. Reports on Field Trials of Tripterygium. (USDA memoranda to Dr. Morton Beroza & Dr. L. M. Pult and to Dr. Morton Beroza & A. F. Sievers).

LIST OF PLANT INTRODUCTIONS AND CULTIVATIONS (PI Numbers and Herbarium Records at the National Arboretum)

PI 77849 - Tripterygium regelii
Received 1928 from the Arnold Arboretum (Origin & destination unknown).

PI 100610 - Tripterygium forrestii
Seeds from southwest China; collected by the Sixth Forest Experimental Station in 1930-1932. Received by Major Lionel de Rothchild, Munden, England (July 2, 1932). (Destination unknown).

PI 105032 - Tripterygium forrestii
Seeds from China; collected by Dr. Sun Yatsen's at Memorial Park, Nanking, China. Presented by H. K. Fu (Director of Botanical Garden). Received March 21, 1934. (Destination unknown).

PI 105330 - Tripterygium forrestii
Seeds presented by Director of Botanical Garden, Dr. Sun Yat-sen's and Memorial Park Commission. Received April 14, 1934. (Destination unknown).

PI 113543 -(N.A.H. 161722) - Tripterygium wilfordii var. exesum
Cuttings from Eih Shih Pa-tu in the Yi Wu District, Chekiang Province. Grown at Glenn Dale (July 1939).

PI 113544 -(N.A.H. 161723) - Tripterygium wilfordii var. exesum
Cuttings from Shih Hsia K'ouin Chuki District, Chekiang Province. Grown at Glenn Dale (July 1939).

PI 113790 - Tripterygium sp.
Cuttings collected by Lui, 1936, from Erhshih Pa-tu in the Yi Wu District, Chekiang Province. (Destination unknown).

PI 112754 - Tripterygium sp.
Cuttings collected by Peter Liu and forwarded by Fred J. Rossiter (Acting Agricultural Commissioner - American Consulate, Shang Hai). Received November 21, 1935. Collected near Erhshih Pa-tu in the Wu District, Chekiang Province. (Destination unknown).

PI 112755 - Tripterygium sp.
Same as preceeding but collected near Shih-Hsia-K'Qunin Chuki District.

PI 242417 - Tripterygium forrestii
Cuttings collected by Fred Meyer (USDA) from Botanical Garden, Edinburg, Scotland, and received September 11, 1957.

PI 316062 - Tripterygium regelii
Seeds from Kusatsu, Gumma, Japan. Collected by Doleshy (from Seattle, Washington). Received July 27, 1966. Sent to Glenn Dale.

Tripterygium regelii (N.A.H. Specimen)
Planted at the Botanical Garden, Koishi Kawa, Tokyo, Japan. J. Ohwi, May 30, 1962.

Tripterygium regelii (N.A.H. Specimen)
Cultivated at Arboretum of Barnes Foundation, Merion, Pennsylvania. (June 19, 1968).

Tripterygium regelii (N.A.H. 1862863)
Arnold Arboretum - Harvard (# 5716-A). Seed collected by J. C. Jack, 1905, from Pukttam, near Seoul, Korea. Grown August 5, 1940.

Tripterygium wilfordii (N.A.H. Specimen)
Nursery of H. A. Hesse, East Friesland, W. Germany. Collected by Fred Meyer, September 8, 1959.

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cc: A. S. Barclay
G. Christenson

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