A REVISION OF ISOPYRUM, DICHOCARPUM AND THEIR ALLIES

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Isopyreae, the tribe containing the genus *Isopyrum*, is well defined by the small chromosomes whose basic number is 7, and by the formation of follicles. The delimitation of taxa within this group has already been attempted by Maximowicz (1883), Franchet (1897), Finet and Gagnepain (1904), Drummond and Hutchinson (1920) and Ulbrich (1925) but it does not seem to be settled. Recently, Wang and Hsiao (1964) described a new genus *Dichocarpum* and transferred to it many of the Asiatic species of *Isopyrum*. The authors wish to take this opportunity to criticize the circumscriptions of genera and infra-generic taxa in this tribe. The authors would like to express their sincere thanks to Professor S. Kitamura of Kyoto University and to Dr. H. R. Fletcher of the Royal Botanic Garden, Edinburgh who generously gave them every facility to carry out this work. They are also grateful to Mr. B. L. Burtt and Mr. I. C. Hedge of the Royal Botanic Garden, Edinburgh and Dr. W. T. Wang of Academia Sinica, Peking for their valuable advice.

The authors agree with Wang and Hsiao (1964) about the separation of *Dichocarpum* from *Isopyrum*. The characters by which the genus *Dichocarpum* is defined are as follows: follicles constantly 2 in number, connate at the base, much divaricate, with a longitudinal vein or veins at each side; pedicels usually swollen at the top; petals with the stalk longer than the blade; leaves pedately (3–) 5–15-foliolate; leaf-lobes or leaf-teeth distinctly emarginate and with a minute gland at the apex; inflorescence dichasial. The last two are often found also in other genera, but are especially remarkable in *Dichocarpum*. Plants of this genus are perennials with a leafy, branched stem and rather small flowers. The distribution areas of the species are well concentrated in the temperate zone of Eastern Asia. In the other genera of *Isopyreae*, the carpels are free (1–) 2–8(–10) or more and variable in number, the petals shortly stipitate, sessile or absent, the pedicels are not swollen at the top and the leaves are ternately compound.

In the genus *Dichocarpum*, Wang and Hsiao recognized two sections. Sect. *Dichocarpum* is characterized by the pedicel top swollen semi-spherically or semi-ellipsoidally, and is distributed in China, Himalaya and Taiwan. Sect. *Hutchinsonia* is characterized by the pedicel top much swollen and dilated with the enlarged part growing so as to hang over the pedicel, and is distributed in Japan. Many species of Sect. *Dichocarpum* have the leafy branched stem without or with a few radical leaves, flat petaline blade, and subglobular light-brown smooth seeds. But *D. fargesii* is very distinctive in having the follicles narrow and attenuate with two distinct but hardly alate, longitudinal veins at each side and scant transverse veins, black-brown elliptic longitudinally striate-costate seeds, cup-shaped petals and only slightly or hardly swollen pedicel top. By these characteristics it seems better to regard this species as representative of a distinct section, *Fargesia*. In all other species of this genus, the follicles are swollen upwards and semi-obovate in side view

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and alate or angulate along a longitudinal vein. Among them *D. dalzielii*, *D. hypoglaucum*, *D. basilare* and *D. trifoliolatum* are also distinctive in the stem being not leafy but only bracteate, with well developed radical leaves. The petals are cup-shaped in the type specimen of *D. dalzielii*. The seeds vary in shape and colour: elliptic and light-brown in *D. dalzielii* and *D. trifoliolatum*; sub-spherical and blackish-purple in *D. hypoglaucum* and *D. basilare*. For the characteristics of seeds of these species, except *D. dalzielii*, the authors refer to the descriptions of Wang and Hsiao (1964). This group may also be regarded as a distinct section, *Dalzielia*.

Usually, in the species of Sect. *Hutchinsonia*, the seeds are smooth, sub-spherical and light brown, while in *D. trachyspermum* the seeds are lamellate-granulate, and the petals are uni-labial* sometimes curved or rolled inwards at the upper part, and cauline leaves opposite and connate at the base. This species can be regarded as representative of a subsection, *Trachysperma*. Subsect. *Hutchinsonia* can be divided into series based mainly on the petal and the attachment of cauline leaves. In *D. numajirianum* and *D. pterigio-nocaudatum*, the petaline blade is erect and cup-shaped, and the inner and outer walls are bi-lobed or bi-fid into acute lobes, and the leaves, at least the lower ones, alternate. They are classified in Ser. *Numajiriana*. In *D. nipponi-cum*, *D. ohwianum*, *D. dicarpon* and *D. univalve*, the petaline blade is nodding inwards, and bi-labial or uni-labial probably by the extinction of the inner labium. The cauline leaves are essentially alternate; if they appear to be opposite, the leaf-bases of both facing leaves are not connate. They are classified in Ser. *Nipponica*. In *D. stoloniferum* and *D. hakonense*, the petaline blade is erect and cup-shaped, the outer and inner walls are entire or slightly bi-lobed and the inner wall is distinctly shorter than the outer one. The cauline leaves are opposite and usually connate at the base. These two species are classified in Ser. *Stolonifera*.

Next, *Enemion* can be distinguished from *Isopyrum* as a distinct genus by the flowers without petals. The plants of this genus are perennials with leafy branched stems with a few radical leaves at the base, rather small flowers, and 3–10 carpels with few seeds. Tendencies to form an umbellate inflor-escence and tuberous roots are recognizable. The distribution area is North America and Far Eastern Asia.

Leptopyrum is clearly separable from the other genera by the annual habit. Apart from this, the follicles are numerous, 10–20 in number. The branching of the stem shows a somewhat peculiar feature, but it can be considered as a modified dichasium. The petals are tubulose and shortly stalked, and the seeds lamellate-granulate. One species, *L. fumarioides*, is distributed from Eastern Europe through Siberia, Kansu, to Manchuria and Northern Korea as a weed of farms.

Paraquilegia also seems to be separable as a genus by the simple scapose stem with 1–2 bracts, the single large flower and caespitose habit. The radical leaves are well developed, and the rhizome erect, branched and densely covered with the bases of old leaves. The petals are nearly sessile, flat and slightly hollowed near the base. This genus occurs in the alpine zone of Central Asia, Himalaya and China, and grows on sunny rocky places.

* When the blade of the petals consists of one outer wall only or of an inner and outer wall, we refer to this structure as uni- or bi-labial. The top of the wall, especially the outer one may be entire, bilobed or bifid.

Other species, which belong to *Isopyrum* s. str., have a creeping rhizome, branched leafy stem with a few radical leaves at the base, dichasial inflorescence, rather small flowers, shortly stalked petals, and free follicles (1–)2–8(–10) in number. Ulbrich (1925) proposed a genus *Paropyrum* for *Isopyrum anemonoides* Kar. & Kir. According to him, the petals of this species are non-stipitate, cymbiform and saccate at the base. But Maximowicz (1883), Finet and Gagnepain (1904) and Wang and Hsiao (1964) illustrated the tubulose petal of this species, and actually many specimens identical with *I. anemonoides* Kar. & Kir. in other characters have tubulose petals. According to a letter from Wang, all Chinese specimens have tubulose petals as far as he has examined them. In the isotype specimen, *Karelin & Kiriloff* 1162 (K), the petals are distinctly tubulose and shortly stalked. It is clear that *Paropyrum* has tubulose petals and is distinguished from *Isopyrum* which has flat petals. Nevertheless, the authors regard *Paropyrum* not at generic but sectional rank as in the treatment by Wang and Hsiao (1964). A paper on *Isopyrum anemonoides* precedes this one (Notes R.B.G. Edinb. 28: 265–266, 1968). The type species of *Isopyrum* is *I. thalictroides* L. A. Richard (1826) tended to retain *Isopyrum* for *I. fumarioides* and gave a new name *Thalictrella* for *I. thalictroides*, before the establishment of the genus *Leptopyrum* for *I. fumarioides* by Reichenbach (1828) but *Thalictrella* seems to be a nomen nudum and invalid. In the herbarium of the Royal Botanic Garden, Edinburgh, there is a specimen whose petals are not tubulose but only hollowed at the base and shortly stalked. It differs from *I. thalictroides* in the smaller, narrower leaflets and the longer petiolules, and is regarded as a new species, *Isopyrum ludlowii*. *I. thalictroides* and *I. ludlowii* belong to Sect. *Isopyrum*, which has flat petals and is distributed in Europe and Kashmir. *I. anemonoides* and *I. manshuricum* belong to Sect. *Paropyrum*, which has tubulose petals and is distributed in Siberia, Central Asia, Himalaya, China and Manchuria.

Among these genera, *Enemion* seems to be the most primitive because of the absence of petals. *Dichocarpum* and *Isopyrum* may have arisen from *Enemion*. *Dichocarpum* is advanced in the connation and the constancy of number in the carpels, the swelling of the pedicel top, the dichasial inflorescence, the pedate leaves, etc., and *Isopyrum* is so in the petal with a short stalk and enlarged blade. In *Dichocarpum*, Sect. *Hutchinsonia* is more advanced than the other sections considering the status of the pedicel top, and Sect. *Dichocarpum* is so considering the reduction of the inner wall of the petal. Sect. *Fargesia* is specialized in the follicle and the seed, and Sect. *Dalzielia* likewise in the scapose stem. In *Isopyrum*, Sect. *Paropyrum* with the tubulose petal is primitive and Sect. *Isopyrum* with the flat petal is more advanced. *Leptopyrum* is considered to be derived from *Isopyrum* Sect. *Paropyrum*, and *Paraquilegia* from Sect. *Isopyrum*, owing to having similar petals. *Semiaquilegia* also seems to be derived from Sect. *Isopyrum* in a different way from *Paraquilegia*, and is specialized in having the scales transformed from the innermost members of stamens, and sessile petals saccate at the base. In *Aquilegia*, the projection at the base of the petal is further elongated into the spur and the flower becomes larger. By having such scales, *Aquilegia* and *Semiaquilegia* are distinguishable as a distinct subtribe, *Aquilegiinae*, from the group of other genera, *Isopyrinae*.

Enumeration of Genera and Species in Subtribe Isopyrinae

Isopyrinae Spach, Hist, Nat. Veg. 7: 326 (1839) ut Sect. Isopyrinae, excl. *Aquilegia*.

Enemion Rafin. in Jour. Phys. 91: 70 (1820).

Perennis caule ramoso foliato, foliis ternatim compositis. *Petala* desunt. *Folliculi* 3–10 liberi.

Sect. Enemion—*Flores* solitarii.

E. biternatum Rafin. (Typus sect.), *E. stipitatum* (A. Gr.) Drumm. & Hutch., *E. occidentale* (Hook. & Arn.) Drumm. & Hutch., *E. occidentale* var. *coloratum* (Greene) Drumm. & Hutch.

Distr.: North America.

Sect. Umbellata Drumm. & Hutch. in Kew Bull. 159 (1920)—*Flores* umbellati.

E. raddeanum Regel (Typus sect.), *E. hallii* (A. Gr.) Drumm & Hutch.

Distr.: *E. hallii* in N America; *E. raddeanum* in E Asia, Manchuria, Ussuri, N Korea, N and Central Honshu.

Dichocarpum W. T. Wang & Hsiao, in Acta Phytotax. Sin. 9: 323 (1964).

Perennis caule ramoso, foliis pedatim compositis raro ternatis. *Petala* longe stipitata, stipite limbo longiore. *Folliculi* 2 basi connati, facie longitudinaliter nervati.

Sect. Dichocarpum.

Dichocarpum Sect. Dichocarpum Ser. Sutchuenensia W. T. Wang & Hsiao l.c. 324, pro parte.

Caulis foliatus. *Folia* radicalia nulla vel pauca; caulina alternata vel subopposita, petiolis non connatis. *Pedicelli* apice tumescentes. *Petala* plana vel leviter concava apice bilobata vel integra. *Folliculi* semi-obovati vel obovato-lineares, facie alati vel angulati transverse nervati. *Semina* subglobosa laevia fulva.

D. sutchuenense (Franch.) W. T. Wang & Hsiao (Typus sect.), *D. auriculatum* (Franch.) W. T. Wang & Hsiao, *D. franchetii* (Fin. & Gagnep.) W. T. Wang & Hsiao, *D. adiantifolium* (Hook. f. & Thoms.) W. T. Wang & Hsiao, *D. arisanense* (Hayata) W. T. Wang & Hsiao.

Distr.: Himalaya, N. Burma, China—Szechuan, Yunnan, Kweichow, Hupei, Hunan, Kwangsi, Chekiang and Taiwan.

Sect. Dalzielia Tamura & Lauener, **sect. nov.**

Dichocarpum Sect. Dichocarpum Ser. Sutchuenensia W. T. Wang & Hsiao, l.c. 324, pro parte.

Caulis scaposus bracteatus. *Folia* radicalia magna rosulata 3–5 in numero. *Bractea* subopposita basi non connata. *Pedicelli* apice tumescentes. *Petala* poculiformes. *Folliculi* semi-obovati vel obovato-lineares, facie alati vel angulati transverse nervati. *Semina* subglobosa vel ellipsoidea, laevia, fulva vel atropurpurea.

D. dalzielii (Drumm. & Hutch.) W. T. Wang & Hsiao (Typus sect.), *D. trifoliolatum* W. T. Wang & Hsiao, *D. basilare* W. T. Wang & Hsiao, *D. hypoglaucum* W. T. Wang & Hsiao.

Distr.: China—Szechuan, Yunnan, Kweichow, Kwangtung, Kwangsi, Kiangsi, Chekiang.

Sect. FARGESIA Tamura & Lauener, **sect. nov.**

Dichocarpum Sect. Dichocarpum Ser. Fargesiana W. T. Wang & Hsiao, l.c. 329.

Caulis foliatus nonnulli fasciculati. *Folia* radicalia in anthesi plus minus adsunt; caulina plerumque subopposita, petiolis non connatis. *Pedicelli* apice vix tumescentes. *Petala* poculiformes. *Folliculi* lineares basi vix attenuati valde divaricati, facie distincta longitudinaliter 2 nervati vix alati vix transverse nervati. *Semina* ellipsoidea longitudinaliter costatostriata fusca.

D. fargesii (Franch.) W. T. Wang & Hsiao (Typus sect.).

Distr.: China—Szechuan, Kweichow, Kansu, Hupeh, Hunan and Shensi.

Sect. HUTCHINSONIA W. T. Wang & Hsiao, l.c. 330.

Caulis foliatus. *Folia* radicalia nulla vel pauca. *Pedicelli* apice sub fructu valde tumescentes conicus subtus concavus. *Folliculi* semi-obovati vel obovato-lineares, facie alati vel angulati transverse nervati. *Semina* subglobosa fulva.

Subsect. Hutchinsonia—*Semina* laevia.

Ser. Numajiriana Tamura & Lauener, **ser. nov.**

Folia caulina alternata vel subopposita, petiolis non connatis. *Petala* erecta poculiformes, bifida vel bilobata, lobis acutis.

D. numajirianum (Makino) W. T. Wang & Hsiao (Typus sect.), *D. pterigionocaudatum* (Koidz.) Tamura & Lauener, **comb. nov.** (= *Isopyrum pterigionocaudatum* Koidz. in Acta Phytotax. Geobot. 9: 72, 1940).

Distr.: Japan—Western Honshu and Eastern Shikoku.

Ser. Nipponica Tamura & Lauener, **ser. nov.**

Folia caulina alternata vel subopposita, petiolis non connatis. *Petala* bilabiata vel unilabiata (i.e. plana), nutantes vel incurvata.

D. nipponicum (Franch.) W. T. Wang & Hsiao (Typus sect.), *D. ohwianum* (Koidz.) Tamura & Lauener, **comb. nov.** (=*Isopyrum ohwianum* Koidz. in Acta Phytotax. Geobot. 9: 108, 1940), *D. dicarpon* (Miq.) W. T. Wang & Hsiao, *D. univalve* (Ohwi) Tamura & Lauener, **stat. nov.** (=*Isopyrum dicarpon* var. *univalve* Ohwi in Feddes Rep. 36: 49, 1934).

Distr.: Japan—Honshu, Shikoku and Kyushu.

Ser. Stolonifera Tamura & Lauener, **ser. nov.**

Folia caulina opposita, petiolis plerumque connatis. *Petala* erecta poculiformia, muro interno quam muro externo distincte breviore, vix vel tantum leviter bi-lobata.

D. stoloniferum (Maxim.) W. T. Wang & Hsiao (Typus ser.), *D. hakonense* (Maekawa & Tuyama ex Ohwi) W. T. Wang & Hsiao.

Distr.: Japan—Central Honshu, Pacific side.

Subsect. Trachysperma Tamura & Lauener, **subsect. nov.**

Folia caulina opposita, petiolis connatis. *Petala* plana, erecta vel superne incurvata. *Semina* lamellato-granulata.

D. trachyspermum (Maxim.) W. T. Wang & Hsiao (Typus subsect.).

Distr.: Japan—Honshu, Shikoku and Kyushu.

Folia caulina opposita, petiolis connatis. *Petala* plana, erecta vel superne incurvata. *Semina* lamellato-granulata. *D. trachyspermum* (Maxim.) W. T. Wang & Hsiao (Typus subsect.).

Distr.: Japan—Honshu, Shikoku and Kyushu.

Isopyrum L. Sp. Pl. 557 (1753).

Perennis caule ramoso foliato, foliis ternatim compositis. *Petala* breviter stipitata, stipite limbo breviore. *Folliculi* 1–5 liberi.

Sect. PAROPYRUM (Ulbr.) W. T. Wang & Hsiao, l.c. 321.

Paropyrum Ulbr. in Notizbl. Bot. Gart. Berlin 9: 218 (1925).

Petala tubulosa.

I. anemonoides Kar. & Kir. (Typus sect.), *I. manshuricum* Komar.

Distr.: *I. anemonoides* in Siberia, Central Asia, Afghanistan, Himalaya, China—Kansu, Sinkiang and Chinghai; *I. manshuricum* in Manchuria and Ussuri.

Sect. ISOPYRUM.

Petala plana vel leviter concava, non tubulosa.

I. thalictroides L. (Typus sect.), *I. ludlowii* Tamura & Lauener.

Distr.: *I. thalictroides* in Europe; *I. ludlowii* in Kashmir.

Isopyrum ludlowii Tamura & Lauener, **sp. nov.**

Rhizoma ca. 1·5 mm crassum superne basibus petiolorum veteribus dense tectum. *Caulis* 8–20 cm altus superne ramosus papilloso-pilosus inferne glabratus. *Folia radicalia* 3–5 in numero ad 12 cm longa 3–4-ternata, foliolis oblongis vel obovatis vel flabellatis, 1·2–5 × 1–4·5 mm, integris vel 3-lobatis ad 3 partitis, lobis vel segmentis elliptico- vel obovato-oblongis 0·7–1·2 mm latis basi cuneatis apice obtusis vel rotundatis, utrinque papilloso-pilosis, petiolis 3·5–8 cm, petiolulis primis 8–30 mm, secundis 2–13 mm, tertiis ad 6 mm longis papilloso-pilosis. *Folia caulina* inferiora ad 2·5 cm longa 2–3- ternata breviter petiolata subopposita, petiolis non connatis, foliolis iis radicalibus similibus 2–7 mm × 1·5–5 mm saepe 3 partitis, segmentis integris, stipulis liberis ovatis vel lanceolatis ad 1·8 mm longis acutis vel acuminatis; folia caulina superiora 2-ternata iis inferioribus similia sed minora et breviter petiolata et petiolulata, subopposita vel alternata. *Inflorescentia* dichasialis, sed ramis lateralibus non aequantibus saepe ramo unico tantum evoluto, 1–3- florifera. *Pedicelli* in anthesi, 2·5–3 cm longi, post anthesi elongati ad 6 cm longi, papilloso-pilosi. *Sepala* 5 elliptica vel ovato-elliptica c. 10 × 5 mm apice obtusa vel acutiuscula basi subcuneata. *Petala* 5 oblonga vel obovato-oblonga 2·5–2·8 × 1·2–1·7 mm inferne cymbiformes concava apice leviter bilobata, breviter stipitata vel unguiculata. *Stamina* 4–5 mm longa, filamentis filiformibus vel plus minus dilatatis, antheris ellipticis 0·5 mm longis. *Carpella* 4–5 in numero utrinque attenuata, stylis elongatis c. 1·5 mm longis, stigmatibus plus minus incurvatis.

Differt a *I. anemonoides* et *I. thalictroides* foliis 3–4- ternatis, petiolulis longioribus, foliolis minoribus.

KASHMIR: Lidar Valley, near Pahlgam, 3050 m, dry situation in clefts of rocks, 5 vi 1939, *Ludlow* 69 (holo—E, iso—BM).

Leptopyrum Reichb., Conspect. Reg. Veg. 192 (1828).

Annuus caule ramoso foliato, foliis ternatim compositis. *Petala* tubulosa breviter stipitata, stipite limbo breviore. *Folliculi* 10–20 liberi.

L. fumarioides (L.) Reichb. (Typus gen.).

Distr.: E Europe, Siberia, Mongolia, China—Kansu, Manchuria and N Korea.

Paraquilegia Drumm. & Hutch. in Kew Bull. 156 (1920).

Perennis dense caespitosa, caule simplici 1–2 bracteato, foliis radicalibus pluribus ternatim compositis. *Flos* solitarius magnus. *Petala* unguiculata vel fere sessilia, plana vel basi concava. *Folliculi* 2–10 liberi. *Rhizoma* erectum ramosum superne basibus petiolorum veteribus dense tectum.

P. microphylla (Royle) Drumm. & Hutch. (Typus gen.), *P. anemonoides* (Willd.) Ulbr., *P. caespitosa* (Boiss. & Hohen.) Drumm. & Hutch., *P. uniflora* (Aitch. & Hemsl.) Drumm. & Hutch., *P. chionophila* Gilli.

Distr.: *P. microphylla* in Himalaya, Central Asia, China—Szechuan, Yunnan, and Tibet; *P. anemonoides* in Iran, Afghanistan, Himalaya, Central Asia, China—Sikang and Kansu; *P. chionophila* in Afghanistan. *P. uniflora* and *P. caespitosa* from Afghanistan may be conspecific and *P. anemonoides* is certainly closely allied to *P. microphylla*. However, further investigation of the genus is necessary.

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