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The taxonomic value of fruit structure in the Chinese endemic genus Dickinsia (Apiaceae)

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The monotypic *Dickinsia* Franch. is misplaced in its current position in the tribe Hydrocotyleae and is transferred to the tribe Mulineae. Its mericarps are strongly dorsally compressed and the lateral ribs of each mericarp are much more prominent than the dorsal rib. The carpophore is free. These characters are typical for genera of the Mulineae but are obviously different from other genera of Hydrocotyleae, which all have laterally compressed mericarps, dorsal ribs which are more expanded than the lateral ribs and an absence of free carpophores.

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Introduction

The monotypic genus *Dickinsia* Franch. is one of only three genera of "Hydrocotyloideae" present in China (Shan & Sheh 1979). Pimenov & Leonov (1993) placed *Dickinsia* in the subtribe Hydrocotylinae (tribe Hydrocotyleae of the subfamily Hydrocotyloideae) together with nine other genera of this subtribe and four of the subtribe Xanthosiinae. These are *Centella* L., *Chlaenosciadium* C. Norman, *Homalosciadium* Domin, *Hydrocotyle* L., *Micropleura* Lag., *Neosciadium* Domin, *Platysace* Bunge, *Trachymene* Rudge and *Uldinia* J.M. Black in Hydrocotylinae, and *Actinotus* Labill, *Pentapeltis* Bunge, *Schoenolaena* Bunge and *Xanthosia* Rudge in Xanthosiinae.

Norman (1922) pointed out that *Dickinsia* is different from *Hydrocotyle* and *Micropleura* in the dorsally, not laterally compressed fruit. Sheh and Su (1987) considered *Dickinsia* to be more specialized than *Hydrocotyle* and *Centella* because of its two broad bracts, fruit ridges with "five wings" (?) and compound umbel. However the details about the fruit are not clear and actually incorrect (wings are absent). Therefore a study of the anatomy of the fruit of *Dickinsia* was done for three reasons. (1) The anatomy has remained unknown, even in the Chinese Flora (Shan & Sheh 1979). (2) To evaluate the systematic value of the fruit anatomy by comparing the structure with genera in Drude's (1898) "Hydrocotyloideae". Until now the phylogenetic relationship of *Dickinsia* has remained unknown. (3) To explore similarities between *Dickinsia* and other genera.

Materials and methods

Mature fruits of sixteen species of "Hydrocotyloideae" representing sixteen genera were obtained from CANB, CBG (CBG was incorporated into CANB), L, NAS, MICH, PE, PERTH, PRE and UPNG. Voucher specimens are included in Table 1. Mature fruits were rehydrated and placed in FAA for

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Table 1. Voucher specimens of Apiaceae species used in the anatomical study.

Species	Voucher specimens
Actinotus minor DC.	Van Steenis 22889 (PE)
Centella asiatica (L.) Urban	Demoulin 5882 (UPNG)
Chlaenosciadium gardneri C. Norman	PERTH 03504128
Dickinsia hydrocotyloides Franch.	NAS 403956
Diplaspis hydrocotylea Hook.f.	Verdon 2671 (L)
Hermas capitata L.	Bolus 9111 (PRE)
Homalosciadium homalocarpum (F. Muell.) H. Eichler	Eichler 22047 (CANB)
Hydrocotyle vulgaris L.	Koso-Poljansky 2618 (PE)
Micropleura renifolia Lag.	McVaugh 13003 (MICH)
Neosciadium glochidiatum (Benth.) Domin	CANB 024462
Pentapeltis peltigera (Hook.) Bunge	PERTH 03542033
Platysace lanceolata (Labill.) Druce	Pullen et al. 8592 (PE)
Schoenolaena juncea Bunge	PERTH 03578860
Trachymene tripartita Hoogl.	Eichler 18197 (PE)
Xanthosia pilosa Rudge	Canning 3919 (CBG)
Uldina mercurialis J.M. Black	Donner 7348 (PE)

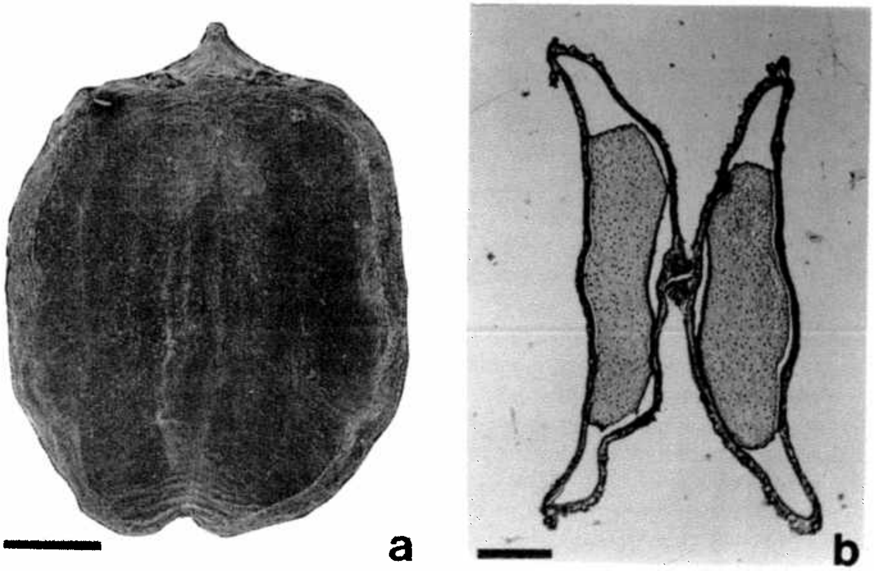
a minimum of 24 h and then treated according to the method of Feder & O'Brien (1968) for embedding in glycol methacrylate (GMA). However, a minimum of 24 h was used for the first two infiltrations in GMA and a minimum of five days for the third infiltration. The capsules containing the material and GMA were placed in an oven at 60° for 24 h. Sections, about 5 µm thick, were cut through the middle of the fruits using a Porter-Blum ultramicrotome. The Periodic acid-Schiff/toluidine blue staining method was used. Photographs were taken using a Leitz Wetzlar microscope and Ilford Pan F film. For SEM studies of the fruit, a JEOL JSM 5600 scanning electron microscope was used. Drawings were done using a camera lucida.

Results and discussion

Mature fruits of *Dickinsia hydrocotyloides* Franch. are square in dorsal view (Fig. 1a), about 2.5 mm long and 2 mm wide, and yellow-brown in colour. The mericarps are strongly dorsally compressed, about 1 mm thick (Fig. 1b), and the lateral ribs are more prominent than the dorsal rib and slightly expanded. Note that the marginal ribs are not developed but that it is the lateral ribs, situated above the lateral vascular bundles, which are prominent (Fig. 2a). The epidermal surface is smooth and the outer wall provided with a cuticle. The mesocarp consists of two to three layers of parenchymatous cells that are flattened periclinally. The endocarp is made of three layers of cells and is strongly lignified. The outer one or two layers are arranged in various directions (mainly transversely) and the innermost layer is longitudinally arranged. Some vascular bundles are associated with vittae that are external to the vascular bundles (intrajugal vittae). There are some vittae scattered in the mesocarp. The commissure (the area where two mericarps join) is very narrow. The carpophore is free and contains two laterally arranged xylem strands (Fig. 2a).

Dickinsia, with its dorsally compressed mericarps, is clearly misplaced in the tribe Hydrocotyleae. The other nine species representing nine genera of Hydrocotylinae, *Centella asiatica* (L.) Urban, *Chlaenosciadium gardneri* C. Norman, *Homalosciadium homalocarpum* (F. Muell.) H. Eichler, *Hydrocotyle vulgaris* L., *Micropleura renifolia* Lag., *Neosciadium glochidiatum* (Benth.) Domin, *Platysace lanceolata* (Labill.) Druce, *Trachymene tripartita* Hoogl. and *Uldinia mercurialis* J.M. Black (Fig. 2d-l respectively), have laterally compressed mericarps. The dorsal ribs are more prominent than the lateral ribs. Vittae, if present, are intrajugal. Carpophores are absent in *Hydrocotyle vulgaris* and *Neosciadium glochidiatum* and present in the other members, but only free in *H. homalocarpum*. Four species representing four genera of Xanthosiinae, viz. *Actinotus minor* DC., *Pentapeltis peltigera* (Hook.)

Fig. 1. Fruit of *Dickinsia hydrocotyloides*. a. dorsal view showing fruit shape, scale bar = 500 μm ; b. transverse section showing structure of the mericarps, scale bar = 300 μm.



Bunge, *Schoenolaena juncea* Bunge and *Xanthosia pilosa* Rudge (Fig. 2m-p respectively), have a very similar fruit structure to the nine genera of Hydrocotylinae. They all have laterally compressed mericarps. *Actinotus minor* is anomalous in having a single mericarp that also appears to be laterally compressed but the absence of a carpophore makes it difficult to tell which ribs are marginal and which one is dorsal. Dorsal ribs tend to be more prominent than lateral ribs in all taxa, giving a rounded to rhomboid shape to the mericarp when viewed in transverse section (Fig. 2d-p). Vittae, if present, are of the intrajugal type. Free carpophores are absent except in *Homalosciadium homalocarpum* (Fig. 2f).

The mericarp structure in *Dickinsia* is remarkably similar to that of other genera of the tribe Mulineae, which all have dorsally compressed mericarps with expanded lateral ribs (Drude 1898, Tseng 1976, Henwood & Hart 2001). *Dickinsia* indeed fits comfortably into this group. Two examples, *Diplaspis hydrocotylea* Hook.f., representing an endemic genus in Australia, and *Hermas capitata* L., representing an endemic genus in Africa, were chosen to illustrate this similarity (Tseng 1967, Van den Borre & Henwood 1998, Henwood & Hart 2001) (Fig. 2b & c). It is clear that the expanded lateral ribs, free carpophores, narrow commissures and even the scattered vittae in *Hermas* (although without a visible deposit) are more than just superficial similarities but that they provide convincing evidence of the true affinities of *Dickinsia*. Note that the two xylem strands are arranged laterally in all three of these species. Lateral ribs are more expanded than dorsal ribs and the commissure is very narrow, resulting in a triangular shape when the mericarp is viewed in transverse section. This differs from other apioid genera with dorsally compressed mericarps where the commissure is often very wide (e.g. the tribe Peucedaneae). Intrajugal vittae occur in both species (with a deposit in *D. hydrocotylea* but without in *H. capitata*), but additional scattered ones are also present in the mesocarp of *H. capitata*, as in *Dickinsia*. This feature is present in some Saniculoideae (Drude 1898). *Dickinsia hydrocotyloides* has a free carpophore with laterally arranged xylem strands, as in *Diplaspis hydrocotylea* and *Hermas capitata* (Fig. 2b, c). Free carpophores should be a more specialized character in the family because they are related to dehiscence of the schizocarp and dissemination.

In this paper, *Dickinsia* is compared with other genera and species of the tribe Hydrocotyleae to show that it is misplaced in this group. Two members of the tribe Mulineae were chosen to show the obvious similarity with the latter tribe. Detailed study of the Mulineae is the topic of another paper (Liu et al. in prep). In recent DNA studies by Plunkett et al. 1996, 1997; Plunkett & Downie 1999; Downie & Katz-Downie, 1999; Plunkett 2001, only a few genera of the Mulineae were included:

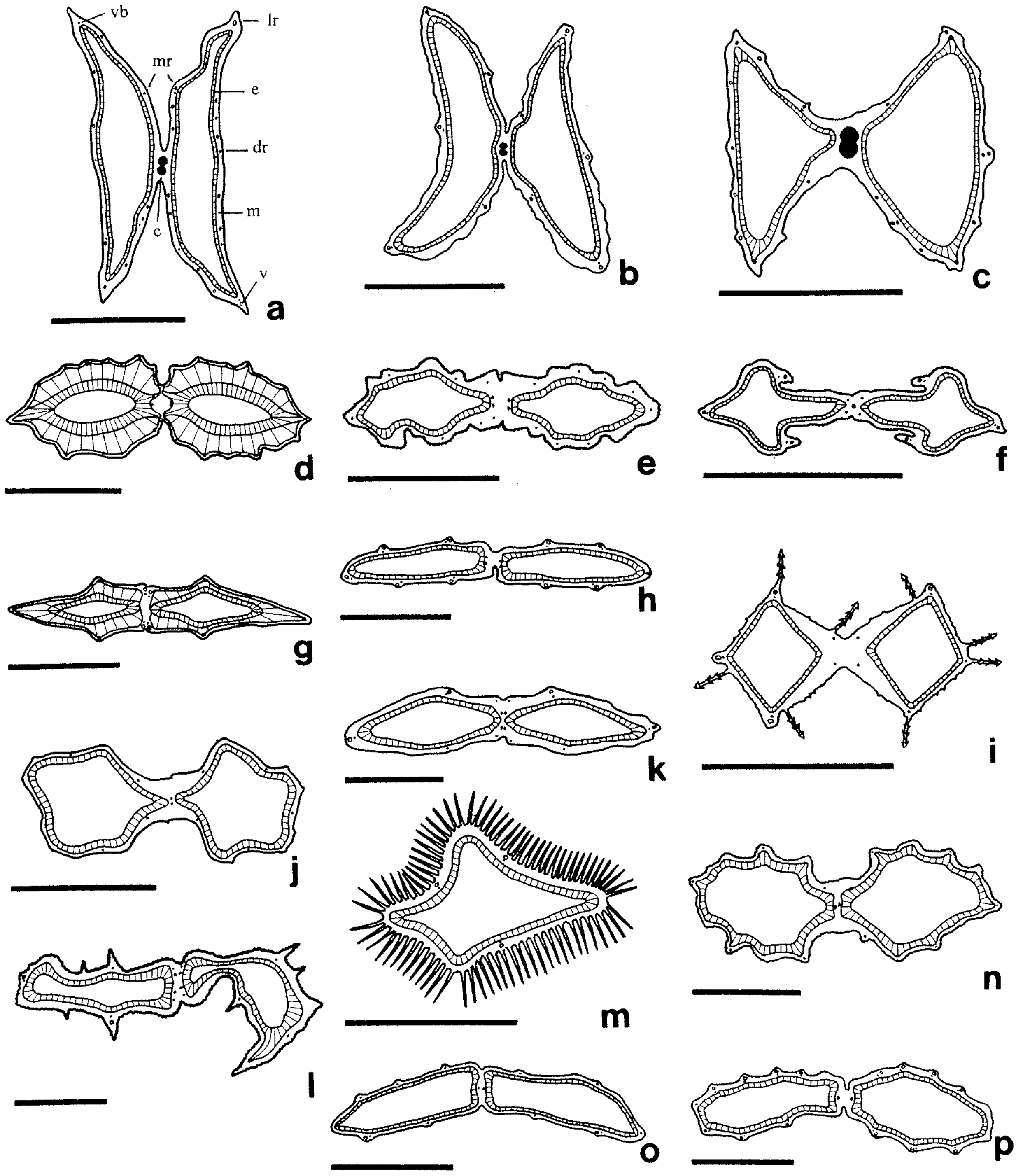


Fig. 2. Fruit structure of "Hydrocotyloideae" as seen in transverse section. a. *Dickinsia hydrocotyloides*; b. *Diplaspis hydrocotylea* Hook.f.; c. *Hermas capitata*; d. *Centella asiatica*; e. *Chlaenosciadium gardneri*; f. *Homalosciadium homalocarpum*; g. *Hydrocotyle vulgaris*; h. *Micropleura renifolia*; i. *Neosciadium glochidiatum*; j. *Platysace lanceolata*; k. *Trachymene tripartita*; l. *Uldina mercurialis*; m. *Actinotus minor*; n. *Pentapeltis peltigera*; o. *Schoenolaena juncea*; p. *Xanthosia pilosa*. (Narrow hatching - lignified endocarp; wide hatching - lignified mesocarp; dots - vascular bundles; circles – vittae; c- carpophore; dr – dorsal rib; e – endocarp; lr – lateral rib; m – mesocarp; mr - marginal rib; v – vitta; vb – vascular bundle). Scale bar = 1 mm (a, b, c), 1.5 mm (f, g, i, k, l, m, p), 2mm (d, e, h, j, n, o).

Azorella Lam., *Bolax* Commerson ex Jussieu, *Bowlesia* Ruiz et Pav., *Eremocharis* Phil., *Klotzschia* Cham. and *Spananthe* Jacq. *Dickinsia* shares with some of these genera the prominent lateral ribs, but *Azorella* appears to be closest since, as with *Dickinsia*, there are no crystals in the mesocarp. *Dickinsia* is obviously very close to *Diplaspis*, but unfortunately this genus has not yet been included in DNA studies. DNA studies placed some of the genera with laterally compressed fruits (Fig. 2d-p) in the Mackinlayeae and other more basal groups (Plunkett 2001), confirming their isolation from the Mulineae and from *Dickinsia*.

This study has shown once again the taxonomic value of fruit characters in unravelling the relationships amongst Apiaceae genera. *Dickinsia* is therefore here transferred from the Hydrocotyleae to the Mulineae, where it is presumably closely related to *Diplaspis* and other genera with dorsally compressed mericarps showing the distinctive lateral wing configuration.

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