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MECONIC ACID AS A CHEMOTAXONOMIC MARKER IN THE PAPAVERACEAE

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Key Word Index—*Papaver*; *Meconopsis*; Papaveraceae; meconic acid; alkaloids; chemotaxonomy.

Abstract—Of 48 species of Papaveraceae examined representing 12 genera, 24 were shown to contain meconic acid and of these, 21 were *Papaver* species. *Meconopsis cambrica* was also found to contain meconic acid, in contrast to other species of *Meconopsis* examined. One recent rearrangement of the Papaveraceae includes a grouping of *Papaver*, *Roemeria* and *Stylomecon* together with *M. cambrica* and our further discovery of meconic acid in two *Roemaria* species examined leads to the conclusion that meconic acid may be a distinctive taxonomic feature of this new grouping. Some attempt has also been made to correlate meconic acid occurrence with that of certain types of alkaloids, and of chelidonic acid.

INTRODUCTION

Meconic acid (**1**) has long been known as a characteristic constituent of opium (the dried latex of *Papaver somniferum*) and its reaction with ferric chloride solution to give a red-coloured complex is used as a confirmatory test for opium. Recently it has been shown to be present in *P. bracteatum* and *P. pseudo-orientale* [1] and we therefore decided to investigate its distribution in *Papaver* and related genera of the Papaveraceae.

RESULTS AND DISCUSSION

Forty eight species, representing 12 genera of the Papaveraceae, were examined and the results recorded in Table 1. These indicate that the occurrence of meconic acid is clearly associated with the genus *Papaver*. Of the 48 species examined, 24 had meconic acid present (a few as traces) and of these 21 were *Papaver* species. In fact, no *Papaver* species showed a definite absence of meconic acid. A further striking result is the presence of significant

Table 1. Presence or absence of meconic acid in certain Papaveraceae species

Species	Meconic acid	Restricted alkaloids
HYPECOIDEAE		
Hypecoum leptocarpum Hook f. & Thoms.	Absent	—
PAPAVEROIDEAE		
Romneyeae		
Romneya coulteri Harv.	Absent	b
Eschscholtzieae		
Eschscholtzia californica Chamisso	Absent	b, g
E. Lobbii Greene	Absent	b, g
Chelidonieae		
Stylophorum diphyllum Nuttall	Absent	—
Chelidonium majus L.	Absent	—
Bocconia cordata Willd. (*Macleaya cordata* R. Br)	Absent	—
Papavereae		
Glaucium flavum Cranz.	Absent	—
Roemaria hybrida L.	Traces	c, h
R. rhoeadiflora Boiss.	Traces	
Dicranostigma franchetianum Fedde	Absent	—
D. lactucoides Hook f. & Thoms.	Absent	—
Meconopsis cambrica (L.) Viguier	Present	h
M. horridula Hook f. & Thoms.	Trace, unconfirmed	—
M. regia G. Taylor	Trace, unconfirmed	—

Table 1— *continued*

Species	Meconic acid	Restricted alkaloids
M. napaulensis DC.	Absent	—
Argemone mexicana L.	Absent	g
A. squarrosa Greene	Absent	
A. ochroleuca Sweet	Absent	
PAPAVER		
Section Orthorhoeades		
P. commutatum Fisch. & Mey.	Present	b, d, h, k
P. postii Fedde	Present	
P. rhoeas L.	Present	
Section Argemonorhoeades		
P. argemone L.	Traces	k
P. minus Boiv ex Bélang	Traces	
P. hybridum L.	Traces	
P. pavoninum Fisch. & Mey.	Traces	
Section Mecones		
P. glaucum Boiss. & Hanska	Present	b, d, e, h, j, k
P. setigerum DC.	Present	
P. somniferum L.	Present	
Section Miltantha		
P. fugax Poir	Present	b, d, e, h, j, k
= *P. caucasicum* Bieb		
P. persicum Lindley	Present	
P. triniaefolium Boiss.	Present	
Section Pilosa		
P. atlanticum Ball	Present	b, d, h, j, k
P. lateritium C. Koch	Present	
P. strictum Boiss. et Bal	Present	
P. pilosum Sibth. & Smith	Present	
Section Oxytona (Macrantha)		
P. bracteatum Lindley	Present	b, d, h, j, k
P. orientale L.	Present	
P. pseudo-orientale Fedde	Present	
Section Scapiflora		
P. nudicaule L.	Present	e, h, j, k
FUMARIOIDEAE		
Corydaleae		
Dicentra spectabilis Lem.	Absent	a
Corydalis claviculata DC.	Absent	
Fumarieae		
Fumaria officinalis L.	Absent	
F. capriolata L.	Absent	

Arranged according to Engler. Protopines, berberines, benzophenanthridines and aporphines are reported present in all these genera [3]; the reported additional occurrence of more restricted alkaloids such as rhoeadines, morphinanes, isopavines, etc. are given in the last column of the table.

(—) indicates no restricted alkaloids reported.

a, cularine; b, 3'4'-benzylisoquinoline; c, isopavine; d, morphinane; e, narceine; f, papaverrubine; g, pavine; h, proaporphine; j, promorphinane; k, rhoeadine.

quantities of meconic acid in the European species of *Meconopsis* (*M. cambrica* (L.) Vig.) which was formerly named *Papaver cambricum* L. In contrast, meconic acid was absent from the Asian species, apart from the traces we found in *M. horridula* and *M. regia* but were unable to confirm due to lack of material. Recently Ernst [2], using botanical characters, has indicated that *M. cambrica* should be separated from the other species of *Meconopsis* and he transferred it to a new group composed of *Papaver*, *Roemaria* and *Stylomecon*. This new grouping is also of interest as we found traces of meconic acid in the two species of *Roemaria* examined. These results therefore seem to indicate that meconic acid may be a distinctive chemotaxonomic feature of *Papaver* and closely related genera.

Certain types of alkaloid are widespread in most of the species of Papaveraceae examined [3]: these are phthalideisoquinolines, 3'4'-benzylisoquinolines, aporphines, protoberberines, berberines, benzophenanthridines and protopine. Other alkaloids seem to have a more restricted distribution, such as the morphinanes, pro-morphinanes, papaverrubines, pro-aporphines, pavines, isopavines, narceine and cularine types. In Table 1 the reported presence or absence of these restricted types in the genera examined by us for meconic acid are given and it will be seen that on the whole those genera containing meconic acid are also rich in the restricted alkaloids; conversely where meconic acid is absent the more restricted alkaloids are much less in evidence.

Chelidonic acid (3) is very closely related to meconic

acid but so far has only been reported in two species of the Papaveraceae, viz. *Chelidonium majus* and *Stylophorum diphyllum*. It occurs commonly in the Liliaceae, Amaryllidaceae, Dioscoridaceae, Rhamnaceae [4] in which meconic acid has not been reported. The biosynthetic pathways to these very similar acids may therefore not be identical.

EXPERIMENTAL

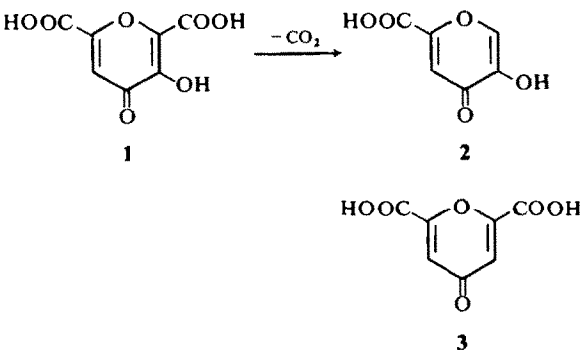
Tests were carried out on plants growing in the Royal Botanic Gardens, Kew; Chelsea Physic Garden, or raised by us from authenticated seeds in our botanic garden in Enfield. In all cases the characters of the mature flowering and fruiting plants were checked against the published description of the species; where appropriate comparisons were made with herbarium material at Kew.

Detection of meconic acid. This can be identified after extraction from the latex by the colour reaction with $FeCl_3$, UV spectra, TLC and MS data [1]. Unfortunately we found it impossible to extract the acid from dried plant material such as capsule, leaf, stem and root, even though these tissues all contained latex vessels. Various solvents such as MeOH, H_2O (and mixtures of these), 5% HOAc and 1MNaOH were tried without success. Even if a soln of pure meconic acid was added to the plant material and dried, it could not be re-extracted which suggests it may be strongly bound to the cell walls, as occurs with ferulic acid [5]. Fresh latex therefore had to be used in the following manner.

(a) Preliminary testing. The stem below the flower or capsule of the plant was severed and the exuding latex immediately applied to a filter paper previously soaked in $FeCl_3$ soln and dried. A reddish-purple colour was putative evidence for the presence of meconic acid: if no colour formed then meconic acid was absent. This method gave some false positives due to pigments in the latex, but no false negatives when later tested by TLC.

(b) Thin-layer chromatography. Latex was immediately transferred to MeOH which made it coagulate. The supernatant was used for TLC (pre-coated cellulose plates; EtOH–H_2O–EtOAc–NH_4OH (0.88) 13:8:7:2) without further purification. The spots were visualized by spraying with a 5% aq. $FeCl_3$, using meconic acid (R_f 0.5) as a marker. If morphine was present it also reacted with the reagent but gave a blue colour at R_f 0.9.

(c) Conversion to comenic acid (2). This was used as a confirmatory test as it was not possible to get an MS by eluting the small quantities of meconic acid obtained by TLC. Some of the MeOH extract of the latex was evapd to dryness in a tube and then heated in an oil bath at 160° for 1 hr; this resulted in almost complete decarboxylation to comenic acid. The residue was dissolved in MeOH and chromatographed on the same system as above. It gave a bluish-red colour with $FeCl_3$ and had an R_f of *ca* 0.4.



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REFERENCES

1. Fairbairn, J. W. and Helliwell, K. (1976) *J. Pharm. Pharmac.* **28**, 940.
2. Ernst, W. (1962) The morphology and classification of the Papaveraceae. Ph.D. Thesis, University of Stanford, Michigan, U.S.A. (via Royal Botanic Gardens, Kew).
3. Santavy, F. (1970) in *The Alkaloids: Chemistry and Physiology* (Manske, R. H. F., ed.), Vol. 12, p. 333. New York.
4. Ramstad, E. (1953) *Pharm. Act. Helv.* **28**, 45.
5. Harris, P. J. and Hartley, R. D. (1976) *Nature* **259**, 508.