New sundew quinone and emergence data

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Keywords: *Drosera*, phytochemistry, naphthoquinones, chemotaxonomy, micro-morphology, emergences.

Introduction

The acetogenic naphthoquinones, plumbagin (P in this paper) and ramentaceone (7-methyljuglone, M in this paper) are important chemotaxonomic markers in sundews (*Drosera* L., Culham & Gornall 1994, Schlauer *et al*. 2017, 2018). Further accessions have been investigated, and the results are presented and discussed here.

Materials and methods

All plants used in the present study were raised from seed or obtained as cultivated specimens from Sonja Schweitzer (Schermbeck): *D. linearis*, *D. uniflora*; Kamil Pasek (Ostrava-Poruda): *D. neocaledonica*; Carni Flora BV (Aalsmeer): *D. cf. paradoxa*. Tubers of species in *D*. sections *Erythrorhiza*, *Stolonifera* and *Ergaleium* were obtained from Greg Bourke (Sydney) and Darren O'Brien (Perth), respectively. The geographic origin of all accessions was traced as far as possible (see Table 1). The methods used were the same as detailed previously (Schlauer *et al*. 2018). Voucher specimens of the investigated plants were deposited in the first author's private herbarium.

Results

Naphthoquinones were detected in all investigated samples except in *D. major* as summarized in Table 1.

Discussion

The presence of P (and absence of M) in *D*. sections *Erythrorhiza* and *Ergaleium* confirms the notion by Culham and Gornall (1994) that P is characteristic in most tuberous sundews while M appears to prevail in *D*. sect. *Stolonifera* instead.

The absence of naphthoquinones is common in pygmy sundews (*D*. sect. *Bryastrum*) and in *D*. sect. *Lasiocephala*, so the detection of P in *D. banksii* (Fig. 1) (the first and so far the only known quinone-producing representative in the latter section) may indicate that this species is close to the branching point at which the ability to produce acetogenic quinones was lost in this alliance.

Drosera serpens is a species in *D*. sect. *Arachnopus* that shows a fairly wide variability in its indumentum and in size. But even the unusually vigorous plant investigated in this study contained P that has so far invariably been detected in *D. serpens*.

Table 1. taxa investigated and quinones detected in the present study. M = 7-methyljuglone (and shinanolone); P = plumbagin (and isoshinanolone); 0 = no quinones found.

Taxon	Provenance	*Drosera* section	Quin.	Reference/Remark
Drosera aberrans (*D. whittakeri* subsp. *aberrans*)	Vic., Australia	*Erythrorhiza*	P	Culham & Gornall (1994) reported P in *D. whittakeri*.
D. lowriei	W.A., Australia	*Erythrorhiza*	P	new (this study)
D. major (*D. bulbosa* subsp. *major*)	W.A., Australia	*Erythrorhiza*	0	Culham & Gornall (1994) reported P in *D. bulbosa*.
D. tubaestylis	W.A., Australia	*Erythrorhiza*	P	new (this study)
D. rupicola (*D. stolonifera* subsp. *rupicola*)	W.A., Australia	*Stolonifera*	M	Culham & Gornall (1994) reported P in this taxon and M in *D. stolonifera* (subsp. *stolonifera*).
D. menziesii	W.A., Australia	*Ergaleium*	P	Culham & Gornall (1994) did not detect quinones in this taxon.
D. modesta	W.A., Australia	*Ergaleium*	P	confirms Culham & Gornall (1994).
D. planchonii (*D. macrantha* subsp. *planchonii*)	Australia	*Ergaleium*	P	Culham & Gornall (1994) did not detect quinones in this taxon.
D. banksii	N W.A., Australia	*Lasiocephala*	P	new (this study)
D. cf. paradoxa	northern Australia	*Lasiocephala*	0	new (this study)
D. aquatica	N.T., Australia	*Arachnopus*	M	confirms Schlauer *et al*. (2017)
D. indica	Ivory Coast	*Arachnopus*	M+P	confirms Culham & Gornall (1994) and Schlauer *et al*. (2018)
D. nana	N.T., Australia	*Arachnopus*	M	new (this study)
D. serpens (very large plant)	N W.A., Australia	*Arachnopus*	P	confirms Schlauer *et al*. (2017)
D. affinis	NE Namibia	*Ptycnostigma*	P	new (this study)
D. cistiflora	South Africa	*Ptycnostigma*	M	confirms Culham & Gornall (1994).
D. uniflora	S Chile	*Psychophila*	M	new (this study)
D. capillaris (long petiole)	Florida, USA	*Drosera*	M	Durand & Zenk (1974) reported P in this taxon (not mentioned in Culham & Gornall 1994).
D. capillaris	Florida, USA	*Drosera*	M	
D. felix	Venezuela	*Drosera*	M	new (this study)
D. filiformis var. *filiformis*	Florida, USA	*Drosera*	M	confirms Culham & Gornall (1994).
D. filiformis var. *floridana*	Florida, USA	*Drosera*	M	new (this study)
D. linearis	Michigan, USA	*Drosera*	M	new (this study)
D. neocaledonica	New Caledonia	*Drosera*	M	new (this study)
D. ultramafica	Philippines	*Drosera*	M+P	new (this study)

Figure 1: *Drosera banksii*. Background: mature plant; A: leaf base with stipule; B: red sessile glands on leaves; C: multiseriate hairs on sepals. All photos: S. Hartmeyer.

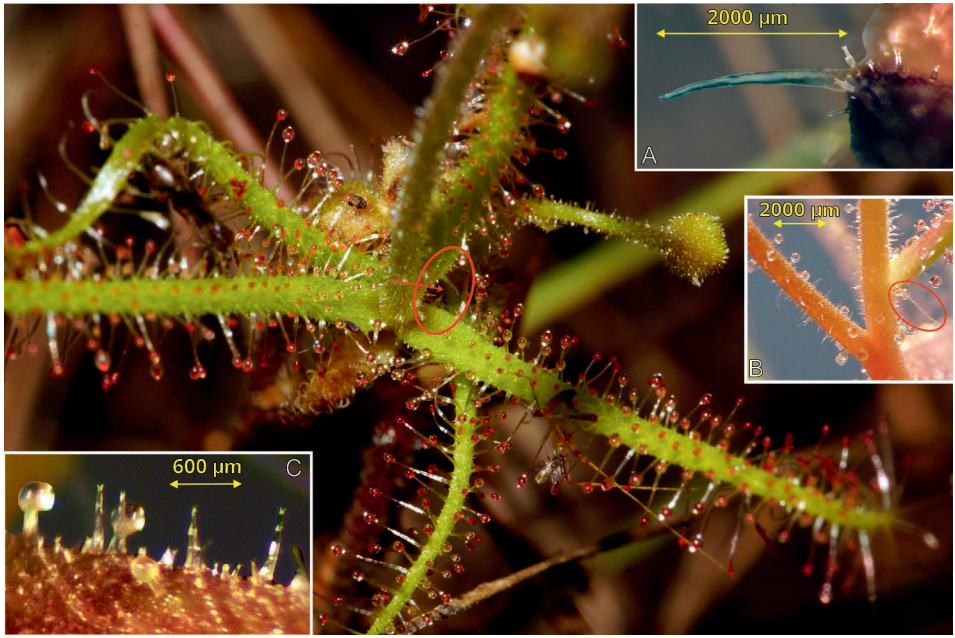

Figure 2: *Drosera nana*. Background: mature stem with leaf bases showing lateral "stipuloid" emergences at leaf bases (arrow and red oval); A: "stipuloid" emergence at side of leaf base; B: elongated double-tipped caps ("hairs") and stalked glands on stem and pedicel; C: double-tipped cap emergences. Background photo: H. and A. Hennern, remaining photos: S. Hartmeyer.

Drosera nana (M in all three distinct populations studied) is occasionally regarded a dwarfed close relative of *D. aquatica*, and its quinone pattern is in line with this view (cf. Schlauer *et al*. 2017). Also, the indumentum is similar (Fig. 2, cf. Schlauer *et al*. 2018) with a predominance of conspicuously elongated double-tipped cap emergences especially along the stems. Frequently "stipuloid" emergences (likewise elongated, double-tipped caps) that are somewhat obscured by the dense stem indumentum are found on either side of the leaf base.

Drosera indica s.str. has been investigated several times before, and the present study discloses that plants from Africa share the same quinone pattern with their Asian conspecifics. As this species is the only known representative of *D*. sect. *Arachnopus* that contains both M and P (which suggests a hybrid origin, cf. Schlauer & Fleischmann 2016), the present result indicates that the hypothetical hybridization event must have occurred before the spread of this species to Africa (where no other species of *D*. sect. *Arachnopus* is known).

Drosera sect. *Ptycnostigma* has been redefined recently (Fleischmann *et al*. 2018) to contain all African species except *D. regia* (*D*. subgen. *Regiae*) and *D. indica* (*D*. sect. *Arachnopus*). Almost all species of *D*. sect. *Ptycnostigma* studied so far contained M, so the detection of P in *D. affinis* provides a valuable tool to define a subgroup of the stem-forming species.

Drosera uniflora is the first species of *D*. sect. *Psychophila* investigated for naphthoquinones. The presence of M confirms gene sequence data (Rivadavia *et al*. 2003) that place it close to *D*. sect. *Drosera* which likewise contains M in the vast majority of its species.

Figure 3: *Drosera ultramafica*. Background: mature plant; A: magnified tip of multiseriate hair (B); B: multiseriate hair; C: leaf bases with stipules and hairs. All photos: S. Hartmeyer.

Figure 4: *Drosera neocaledonica*. Background: mature plant; A: leaf base with stipule and hairs; B: leaf with multiseriate hairs; C: magnified multiseriate hair. All photos: S. Hartmeyer

An unusually long petiole in some individuals of *D. capillaris* from Florida has prompted the suspicion that these may be hybrids with *D. intermedia*. A previous investigation reported P from *D. capillaris*, and *D. intermedia* is likewise known to contain this quinone, so hybrids could be expected to be impossible to distinguish from either parent by their quinone pattern. Our investigation of a "typical" individual of *D. capillaris* (with short petioles) from Florida has, however, demonstrated that it contains M. The presence of only this same quinone in the long-petiolate plant grown from seed (i.e., evidently from a fertile mother) and investigated here is not sufficient to prove its hybrid nature.

The presence of both M and P in *D. ultramafica* (see discussion for *D. indica* above) indicates a hybrid origin. While the morphologically somewhat similar *D. neocaledonica* (cf. Figs. 3 and 4) contains M, the other parent (that contributed the ability to produce P) is somewhat enigmatic, as no close relative of *D. ultramafica* containing P is known in SE Asia.

Acknowledgements: This work was supported by the generous donation of seeds of *D. indica* by Matt Hochberg (New York), of *D. capillaris* and *D. capillaris* "long petiole" by Brian Barnes (Longwood), and *D. ultramafica* by Stewart McPherson (Poole), for which we have the pleasure to express our gratitude. We appreciate the careful review and constructive suggestions by Paulo Gonella and Andreas Fleischmann that have led to the improvement of this paper.

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