Variation in floral fragrance of tuberous *Drosera*

Robert Gibson • 5 Kristen Close • Cardiff Heights • NSW, 2285 • Australia • robert.gibson@environment.nsw.gov.au

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Introduction

Floral fragrance is not widely developed in the genus *Drosera*, and little has been written about this feature. Interestingly, most species with fragrant flowers are found in Australia and comprise some pygmy *Drosera* (*Drosera* subgenus *Bryastrum* section *Lamprolepis* Planch.) such as *D. dichrosepala* Turz., D. *enodes* N.G.Marchant & Lowrie, *D. paleacea* subsp. *trichocaulis* (Diels) N.G.Marchant & Lowrie, and D. *roseana* N.G.Marchant & Lowrie (Lowrie 1987) and most of the tuberous sundews (*Drosera* subgenus *Ergaleium*) (Lowrie 1987), such as *D. heterophylla* Lindl. (Bourke & Nunn 2012), *D. praefolia* Tepper (Gibson 1995), *D. prostratoscaposa* Lowrie & Carlquist (Lowrie & Carlquist 1990) and *D. rupicola* (N.G.Marchant) Lowrie (Lowrie 1987). Five species of sundew with sweetly scented flowers have recently been reported from northern South America: *D. amazonica* Rivadavia, A.Fleischm. & Vicent., *D. arenicola* Steyerm., *D. felix* Steyerm. & L.B.Sm., *D. kaieteurensis* Brumm.-Ding., and *D. solaris* A.Fleischm., Wistuba & S.McPherson (Rivadavia *et al.* 2009); all of which are found in *Drosera* subgenus *Drosera* section *Oosperma* Schlauer. This paper presents a summary of my observations of floral fragrance in the tuberous sundew (*Drosera* subgenus *Ergaleium* (DC.) Drude).

Petal fragrance is one of several means that plants use to attract visitors to flowers to facilitate pollination (*e.g.* Miyake & Yafuso 2003). This is particularly important in groups of plants, such as tuberous *Drosera*, for most are self-incompatible and therefore rely on successful cross-pollination in order to set seed (Lin *et al.* 1997).

Over the last 20 years I have opportunistically smelt the flowers of tuberous *Drosera* when encountered in cultivation and in the wild. Some flowers were dissected to identify the source of the volatile compounds. Following Raguso (2004a) the floral scents I detected could be likened to the fragrance of some familiar items: sucrose or nectar = "nectar sweet"; ripe melons or similar smelling fruit = "fruity sweet"; *Dianthus* cultivars = "carnation-like"; or a mix of mold-like aroma combined with the smell of nectar = "musty sweet". To my nose the flowers of some taxa were unscented.

The relative strength of floral odor was also found to vary between taxa, and the threefold classification used here was based on the approximate distance from the flower before the odors were unambiguously detectable (on fine and calm days) and are given as follows: greater than 5 meters = "strong"; between 5 meters and about 0.1 meters = "moderate"; and 0.1 meters or less = "weak".

Flowers of most of the currently described taxa of tuberous *Drosera* were sampled for this project. The exceptions are given below: In the rosetted tuberous *Drosera* (section *Erythrorhiza* (Planch.) Diels): *D. browniana* Lowrie & N.G.Marchant, *D. prostratoscaposa* Lowrie & Carlquist, *D. schmutzii* Lowrie & Conran, and *D. zonaria* Planch.; in the fan-leaved sundews (section *Stolonifera* (Planch.) DeBuhr): *D. monticola* (Lowrie & N.G.Marchant) Lowrie and *D. prostrata* (N.G.Marchant & Lowrie) Lowrie; and in the Rainbow Sundews (section *Ergaleium* (DC.) Drude): *D. gigantea* subsp. *geniculata* N.G.Marchant & Lowrie, *D. neesii* subsp. *borealis* N.G.Marchant, some forms of *D. macrantha* Endl. subsp. *macrantha*, *D. menziesii* R.Br. ex DC. subsp. *menziesii* (orange petal form), *D. menziesii* subsp. *thysanosepala* (Diels) N.G.Marchant, *D. myriantha* Planch., *D. neesii* subsp. *borealis* N.G.Marchant, and *D. prostratoscaposa*.

Results

Flower fragrance was found to be produced by the petals. The results of this study are summarized below and are discussed in accordance to each of the three sections of the subgenus.

Rosetted tuberous *Drosera* (section *Erythrorhiza* (Planch.) Diels)

The majority of the rosetted tuberous sundews sampled had nectar sweet floral fragrance of moderate strength. The exceptions were the fruity sweet scents of flowers of both subspecies of *D. macrophylla* Lindl.

Figure 1: *Drosera macrantha* subsp. *macrantha* "silky sepal form" showing the distinctive hairs on the inflorescence. This sundew, from the Wongan Hills, has sugary sweet scented flowers and thus differs from all other forms of this subspecies sampled for this project.

Figure 2: *Drosera radicans* is one of the few tuberous sundew found to have unscented flowers in this study.

Figure 3: *Drosera moorei* flowers have a nectar sweet scent and wonderful bright yellow color.

Figure 4: *Drosera marchantii* subsp. *marchantii* plants flower in abundance after fire and have large and abundant flowers with a strong fruity sweet scent.

Table 1. Summary of odor type and relative strength of sampled members of *Drosera* subgenus *Ergaleium* section *Ergaleium*. Legend: S = strong; M = moderate; W = weak.
Unscented (to my nose) *D. bicolor* Lowrie & Carlquist, *D. bulbigena* Morrison, *D. marchantii* subsp. *prophylla* N.G.Marchant & Lowrie, *D. microphylla* Endl., *D. radicans* N.G.Marchant (Fig. 2)
Nectar Sweet *D. auriculata* Backh. ex. Planch. (W), *D. graniticola* N.G.Marchant (S), *D. heterophylla* (S), *D. huegelii* Endl. (S), *D. hookeri* R.P.Gibson, B.J.Conn & Conran (W), *D. intricata* Planch. (M), *D. lunata* Buch.-Ham. ex DC. (W), *D. menziesii* subsp. *menziesii* (pink petalled plants) (M), *D. menziesii* subsp. *basifolia* N.G.Marchant & Lowrie (M), *D. modesta* Diels (S), *D. moorei* (Diels) Lowrie (W) (Fig. 3), *D. neesii* Lehm. subsp. *neesii* (M), *D. peltata* Thunb. (W), *D. salina* N.G.Marchant & Lowrie (W), *D. subhirtella* Planch. (M), *D. sulphurea* Lehm. (M), *D. yilgarnensis* R.P.Gibson & B.J.Conn (W), *D. zigzagia* Lowrie (M)
Fruity sweet D. *gigantea* Lindl. subsp. *gigantea* (M), *D. macrantha* subsp. *macrantha* "silky sepal form" (S), *D. marchantii* DeBuhr subsp. *marchantii* (S) (Fig. 4)
Carnation-like *D. erythrogyne* N.G.Marchant & Lowrie (M), *D. pallida* Lindl. (M)
Musty Sweet *D. andersoniana* W.Fitzg. ex Ewart & Jean White (S), *D. macrantha* subsp. *eremaea* N.G.Marchant & Lowrie (M), *D. macrantha* subsp. *macrantha* (most forms) (M), *D. macrantha* subsp. *planchonii* (Hook.f. ex Planch.) N.G.Marchant (M), *D. menziesii* subsp. *penicillaris* (Benth.) N.G.Marchant & Lowrie (S), *D. stricticaulis* (Diels) O.H.Sarg. (M)

Fan-leaved tuberous *Drosera* (section *Stolonifera* (Planch.) DeBuhr)

All members of the fan-leaved sundews sampled were found also to have nectar sweet blossoms, most of which had moderate strength with the exceptions of *D. fimbriata* DeBuhr and *D. platypoda* Turcz. (both strong) and *D. ramellosa* Lehm. (weak).

Rainbow Sundews (section *Ergaleium* (DC.) Drude)

The Rainbow Sundews sampled revealed a greater diversity of floral scents and relative strengths than other members in other sections of the subgenus (Table 1). The sampling included a number of different morphological forms of *D. macrantha* subsp. *macrantha* including a form from near the Wongan Hills that has long silky hairs on the inflorescence (henceforth the "silky-sepal form": Fig. 1) that had a different floral scent to all other plants of *D. macrantha* sampled.

Discussion

In contrast to other subgenera in the genus *Drosera* the majority of tuberous *Drosera* taxa have detectable floral scents; all of which are produced by the petals in the taxa sampled, and only when the flowers were open. In addition, tuberous *Drosera* taxa display a variety of floral scents which may correlate to different classes of scent compounds. Some groups of taxa with shared morphological characters also share the same type of floral aroma, such as: *D. erythrogyne* and *D. pallida*; *D. andersoniana, D. stricticaulis*, and most forms of *D. macrantha* subsp. *macrantha*; and *D. moorei* and *D. zigzagia*. However, there are also taxonomic groups with members with variation in floral scents: such as *D. menziesii* subspecies and for at least one entity in the *Drosera macrantha* complex.

Floral fragrance type does not appear to correlate well with petal color or flower size. It may be that differences in floral attributes have developed between some tuberous *Drosera* where they grow sympatrically to attract insects that act as pollinators with high fidelity to each taxon of sundew. This is important because many taxa of tuberous *Drosera* grow and flower together, and therefore floral aroma may be one way of ensuring compatible pollen is brought between flowers of the same taxon in order to promoting cross-pollination (Raguso 2004b).

Recommendations for Further Work

The human nose is an imprecise tool for quantifying aromas. It is possible to methodically collect floral aromatic compounds by such techniques as headspace sorption, and then identify each aromatic compound and their abundance by gas chromatography and mass spectrometry (*e.g.* Huber *et al*. 2005). Some or all of these techniques could be used to test the flowers of all tuberous *Drosera*. This would allow the results of floral aromatic chemistry to be mapped onto a phylogeny of the subgenus to test the stability of floral scents (and other floral features) in the evolution of the genus; for example, do all yellow-petalled tuberous *Drosera* share the same floral aromatic chemistry, and do they form a natural group derived from one common ancestor?

These techniques could be expanded to include the entire genus, and examine, for example, whether or not the same aromatic floral compounds occur in different subgenera? It could also be that volatile aromatic compounds occur widely in the genus, only some of which are detectable to the human nose.

Conclusions

This pilot study has identified floral fragrance in most tuberous *Drosera* sampled, and found that the nature and strength of the floral odor varies between taxa, but that the broad type of odor is often shared between morphologically similar taxa. I recommend that volatile floral aromatic compounds are examined in a more rigorous way, with analytical equipment to examine the extent and nature of these compounds in the genus. And finally, I found the floral aromas pleasant to irresistible (particularly the carnation-like scent of *D. erythrogyne* and *D. pallida*). Therefore when next you get the chance, I recommended that you take time and smell the *Drosera* flowers.

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