Resolution of the *Drosera peltata* complex (Droseraceae)

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Drosera peltata Thunb. was described from a specimen collection made in 1793 (Thunberg 7720) from the vicinity of current-day Sydney, Australia. In the years that followed at least a dozen morphologically similar taxa were described, often with imprecisely defined characters that led to confusion in the application of available names to plants in the wild and in cultivation. Conn (1981) and Gibson (1993) independently tackled part of this taxonomic problem and this led to one of us (R.G.) continuing the study of the complex as a PhD project at the University of New England. Additional morphological work resulted in the recognition of the *D. peltata* complex as comprising five species (Gibson *et al*. 2012). This paper is a summary of Gibson *et al*. (2012) and was prepared from Gibson's presentation at the 9th ICPS Conference.

Drosera peltata is a tuberous herb with an erect stem with alternate crescentic leaves that ends in a terminal raceme of flowers, and may have a basal rosette formed prior to stem growth. This habit was recognized in several subsequently-described sundews, notably *D. auriculata* Backh. ex Planch., *D. foliosa* Hook.f. ex Planch., *D. gracilis* Hook.f. ex Planch., *D. insolita* Taton, *D. lobbiana* Turcz., *D. lunata* Buch.-Ham. ex DC., *D. nipponica* Masam., and *D. peltata* "Western Australian Form" (Lowrie 1987). These taxa differ from *D. peltata* by such characters as the presence or absence of hairs on the sepal margin and exterior sepal surface, seed size and shape, geographic range, bracteole morphology, and the presence of a basal rosette and whether, if present, it persists to the time of flowering (Clarke 1879; Turczaninow 1854).

Measurements of 294 morphological features from 213 plants of the *D. peltata* complex were made. Where available, measurements were taken from type collections in order to clarify taxon concepts and to assist in the application of available names. Of the features measured, 198 were qualitative characters. Data was subsequently analyzed using cluster analysis and ordination techniques (Sneath & Sokal 1973). Despite the promising results of a pilot study, the analysis of a fuller data set had poor resolution and led to the conclusion that the *D. peltata* complex comprised a single, widespread and variable species. This result was at odds with observations of clearly distinct members of this complex that remained distinct in the field, particularly where sympatric, and in cultivation.

Further analysis of the dataset suggested that its high noise to signal ratio was due to missing values (due to a missed growth stage, such as no basal rosette formed; or the plant was picked before seed maturity; or the way the specimen was subsequently pressed) and from the measurement of variable or shared characters that could not define distinct taxa. During this time the important question of "do you really need to measure 294 characters in order to identify a member of this complex?" was posed. As a consequence, a new dataset of 29 characters from 89 Operational Taxonomic Units (OTUs) was compiled that was derived from the most complete specimens from the PhD dataset to which new specimens were added. Cluster and ordination analyses on this new dataset provided support for the recognition of five species within the *D. peltata* complex: *D. auriculata*,

D. hookeri, *D. lunata*, *D. peltata*, and *D. peltata* "Western Australian Form" (now *D. yilgarnensis* R.P.Gibson & B.J.Conn). These five taxa were also supported by preliminary analysis of molecular data and the different ecological niches (which occasionally overlap) and geographic ranges that they occupy (Gibson *et al.* 2012).

Once the final taxa had been identified, this led to the quest to assign appropriate type specimens. For *D. hookeri* (Gibson *et al.* 2010) and *D. peltata* (Conn 1981), this work had been done before. In the case of *D. auriculata*, the type collection had been identified in the original description (Planchon 1848). This collection is housed at the herbarium of the Royal Botanic Gardens in Kew, England, and contains three other collections (all of which are *D. peltata*). Thus we assigned one plant with as many characters as possible (*i.e.* basal rosette, cauline leaves, and inflorescence) in the type collection as the lectotype for this taxon; the other plants in that collection became isolectotypes. Assigning a lectotype to *D. lunata* was relatively straightforward once the name for this taxon had been resolved. This widespread member of the group had been described multiple times in the last 200 years. However, de Candolle's (1824) circumscription had priority. Therefore a specimen with most of the characters of this taxon, from a collection cited by de Candolle, was designated as the lectotype.

The five species recognized are briefly described below. Specific rank was chosen to be consistent with the combinations of co-varying characters used to define other species in *Drosera* subgenus *Ergaleium* (*e.g.* Marchant *et al.* 1982).

Drosera auriculata Backh. ex Planch.

The "Tall Sundew" (*D. auriculata*) is found in seasonally moist soils in south eastern Australia and the northern half of New Zealand (Salmon 2001). This species is distinguished by its glabrous sepals, with an entire to irregularly serrulate margin, and its cylindrical seeds that are usually 0.8 to 1.6 mm long. Plants of *D. hookeri* with glabrous sepals from inland parts of south eastern Australia have frequently been misidentified as *D. auriculata*.

Drosera hookeri R.P.Gibson, B.J.Conn & Conran

Much confusion has surrounded the appropriate name(s) to apply to yellow-green plants with deeply-pitted seeds of the *D. peltata* complex in south eastern Australia and the far north of New Zealand. In Tasmania, Victoria, and South Australia in particular short, multi-stemmed plants with white-petalled flowers with densely hairy sepals (formerly "*D. foliosa*") often grow with or near tall, sparsely branched plants with white or pink-petalled flowers with variably hairy (occasionally glabrous) sepals where they form seemingly stable populations that remain distinct. Plants in our study grouped according to plant stature and the degree of sepal hairiness, but in a way that only allowed for the application for one name at species level, to which *D. hookeri* has priority thereby broadening the scope of the application of this name (Gibson *et al.* 2010). Furthermore, unpublished data on molecular sequences and the percentage of seed set from experimental pollinations of members of the *D. peltata* complex does not support the recognition of different growth forms of *D. hookeri* at specific level.

Drosera lunata Buch.-Ham. ex DC.

Drosera lunata has been reinstated as a species after being sunk to synonymy of *D. peltata* by Diels (1906). Plants are characterized by their (typically) glabrous sepals and small ovoid seeds. This species is now recognized as the most widespread of the tuberous species of *Drosera* and occurs across South East Asia, southern India, the Himalayas, southern China,

South Korea, and southern Japan in addition to northern and eastern Australia. Plants grow in seasonally moist soils and often grow in the hotter (and wetter) months of the year contrary to the usual cool-seasonal growth of most tuberous *Drosera*. In Australia, *D. lunata* has been frequently misidentified as *D. auriculata* on the basis of its glabrous sepals. However, these species differ in seed size and shape and typical flowering season (*D. auriculata*: winter and spring; *vs*. *D. lunata*: summer and autumn) which will enable both species to be differentiated where their ranges overlap between Sydney and the Border Ranges of south eastern Queensland. To complicate matters, a few populations of *D. lunata* from Japan have scattered hairs on their outer sepal surfaces (Mr. Koji Kondo, pers. comm., 2012), but all other characters are typical of this species.

Drosera insolita Taton has been an enigmatic species since it was first described in 1945. It was described from a single herbarium collection of a single plant reportedly collected in central Africa; making it the first and only record of a tuberous *Drosera* from that continent. The plant has few (3 or 4)-flowered inflorescences with bracteoles with dentate margins and was said to rarely produce secondary growth in its leaf axils. After considering all of these factors this taxon was given specific rank (Taton 1945). However, the geographical location written on the voucher was incorrect, and that it had instead been collected from southern China (where *D. lunata* occurs widely) (Dr. Elmar Robbrect, pers. comm., 2002). The bracteoles of plants of *D. lunata* vary greatly in size and shape, and include bracteoles with dentate margins (Yun-Zhen 1981: Fig. 2). Examination of the *D. insolita* specimen revealed that the primary stem had been removed just above its base and the plant had six secondary stems each of which terminated in an inflorescence; thus this specimen in fact had abundant secondary growth. Axillary stems of plants in the *D. peltata* complex produce fewer-flowered racemes than that atop the primary stem. Therefore, when all of these factors were considered *D. insolita* was reduced to synonymy with *D. lunata*.

Drosera peltata Thunb.

The type collection of *Drosera peltata* comprises a single plant (Thunberg 7720) collected when just starting to flower. The pressed partially open flower does not present any styles, and no seed characters are available. However, based on the hairy sepal surface and margin, and the size of the sepals and leaves, the specimen was matched with plants that had informally been called "*D. peltata* 'Red Rosette/White petal form'" (Gibson 1993) thereby resolving a long-standing botanical mystery. From our studies all red-rosetted OTUs grouped together and as a consequence "*D. gracilis*" from Tasmania and the highlands of the south eastern Australian mainland was sunk to synonymy with *D. peltata*. This species inhabits permanent rather than seasonal wetlands. Morphologically similar plants occur along the mountainous spine of the island of New Guinea, however no voucher specimens with pressed open flowers or ripe seed were found to include in the analysis to test if they also belong to this species.

Drosera yilgarnensis R.P.Gibson & B.J.Conn

What was previously referred to as "*D. peltata* 'Western Australian Form'" (Lowrie 1987) has been recognized as a distinct species by our study and described as *D. yilgarnensis*; the specific epithet is based the strong association that this species has with granite outcrops in south western Australia, and that these outcrops are part of the "Yilgarn Craton" that forms most of the bedrock of this part of the country. Unlike other members of the *D. peltata* complex this species always forms basal rosettes and is also characterized by flowers with glandular hairy sepals and between 30 and 60 style segments (Fig. 1).

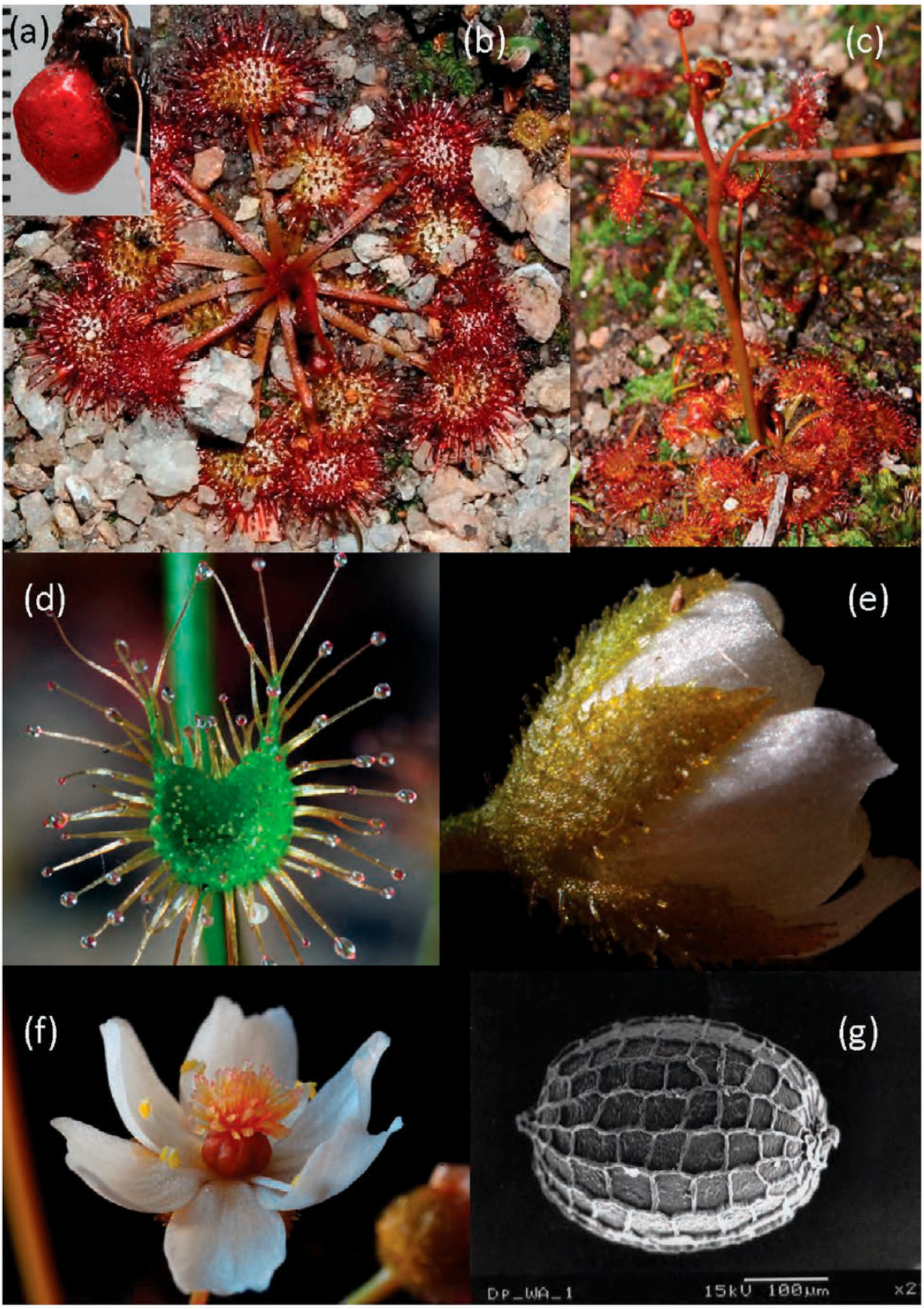

Figure 1: Photomosaic of *Drosera yilgarnensis*. (a) tuber; (b) well-developed basal rosette and developing stem; (c) plant with a rapidly growing stem with developing terminal racemes; (d) cauline leaf; (e) glandular hairy sepals on an opening flower; (f) open flower showing the multidivided styles; and (g) SEM of a ripe seed from P. Mann 18/2003 & R. Gibson (NSW). Photos (a) to (f) by R. Gibson; photo (g) by P. Littlefield.

The apparent mismatch of existing classifications to members of the *D. peltata* complex ultimately led to the collection of additional vouchers of the complex from across its range from which morphological data was collected and subsequently analyzed. Initial results were discouraging due to the inclusion of measurements from characters with poor fidelity to taxon limits and missing values in the dataset. Whilst morphological analysis is by its very nature an iterative process it is still possible to make an educated guess on the main characters to target and the literature provides studies that can help to get you started, *e.g. Drosera indica* complex (Susandarini *et al*. 2002); and *Sarracenia* species (Schnell & Krider 1976).

The main lessons learnt from this project are: (1) regular on-going data analysis during the data-collection stage helps avoid last-minute surprises in a project; (2) data quality is more important than data quantity; and (3) persistence does pay off. The most useful characters we found to distinguish between the five different species of the *D. peltata* complex are: (1) the nature of the sepal margin; (2) the degree of division of the styles; (3) seed size and shape; and (4) seed surface texture. Further study on the different forms of *D. hookeri* appears warranted to test whether it is appropriate to formally recognize any of them and, if so, at what taxonomic rank. In conclusion, morphological analysis is a useful tool for testing taxon concepts and limits and so far appears to be underutilized in its application to the taxonomy of carnivorous plants.

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References

Candolle, A.P. de. 1824. Droseraceae. In: A.P. de Candolle (ed.). Prodromus systematis naturalis regni vegetabilis. Treuttel and Wutz, Paris. pp. 317-320.

Clarke, C.B. 1879. Droseraceae. In: J.D. Hooker (ed.). The Flora of British India. L. Reeve & Co., London. pp. 423-425.

Conn, B.J. 1981. The *Drosera peltata-D. auriculata* complex. Journal of the Adelaide Botanic Gardens 3: 91-100.

Diels, L. 1906. Droseraceae. In: A. Engler (ed.). Das Pflanzenreich: regni vegetabilis conspectus. Engelmann, Leipzig, Germany. pp. 1-137.

Gibson, R. 1993. A closer look at *Drosera peltata* and *D. auriculata* in western Sydney. Bulletin of the Australian Carnivorous Plant Society 12: 11-17.

Gibson, R., Conn, B.J., and Bruhl, J.J. 2012. Morphological evaluation of the *Drosera peltata* complex (Droseraceae). Australian Systematic Botany 25: 49-80.

Gibson, R., Conn, B.J., and Conran, J.G. 2010. *Drosera hookeri* R.P.Gibson, B.J.Conn & Conran, a replacement name for *D. foliosa* Hook.f. ex Planch. *Nom illeg.* (Droseraceae). Journal of the Adelaide Botanic Gardens 24: 39-42.

Lowrie, A. 1987. Carnivorous Plants of Australia: Vol. 1. University of Western Australia Press, Nedlands.

Marchant, N.G., Aston, H.I., and George, A.S. 1982. Droseraceae. In: A.S. George (ed.). Flora of Australia. Vol. 8. Australian Government Publishing Service, Canberra. pp. 9-64, 77, 383-385.

Salmon, B. 2001. Carnivorous Plants of New Zealand. Ecosphere Publications, Auckland.

Schnell, D.E., and Krider, D.W. 1976. Cluster analysis of the genus *Sarracenia* L. in Southeastern United States. Castanea 41: 165-176.

Sneath, P.H.A., and Sokal, R.R. 1973. Numerical Taxonomy: The Principles and Practice of Numerical Classification. Freeman, San Francisco.

Susandarini, R., Collins, G.G., Lowrie, A., and Conran, J.G. 2002. Morphological variation within the *Drosera indica* (Droseraceae) complex in northern Australia. Australian Journal of Botany 50: 207-214.

Taton, A. 1945. Nouveau *Drosera* du Congo Belge. Bulletin du Jardin Botanique de l'État à Bruxelles 17: 301-311.

Turczaninow, N. 1854. Animadversiones ad primam partem herbarii Turczaninowiani, nune universitatis caesereae charkowiensis. Bulletin de la Societe des Naturalistes de Moscou 27: 271-372.

Yun-Zhen, R. 1981. On the Chinese species of *Drosera* L. Acta Phytotaxonomica Sinica 8: 339-344.