Taxonomy and breeding systems of the *Drosera peltata* complex (Droseraceae)

Robert Gibson

BSc (Hons)
University of Tasmania

BSc
Macquarie University

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University of New England
Armidale, NSW 2351, Australia

Declaration

I certify that the substance of this thesis has not already been submitted for any degree and is currently not being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

Robert Gibson

Abstract

Literature, and personal observations, suggested that the *Drosera peltata* complex consisted of up to 12 species in Australia, Asia and Africa. The taxonomy of the complex was controversial, making it ideal for testing species limits, and the morphological, genetic, phylogenetic and biological species concepts.

Species limits of 10 species and 7 putative taxonomic entities were tested by phenetic analysis, using clustering and ordination of 243 herbarium samples and 294 characters. Type specimens were included to consider the application of names. According to morphology, two species were recognised: *D. bicolor* and *D. peltata*.

Phylogenetic analysis using nuclear (ITS1, ITS2 and 5.8 S), and the chloroplast *trnL* sequences revealed that the *D. peltata* complex is non-monophyletic. *Drosera peltata* 'Western Australian Form' grouped apart from the remainder of the complex, indicating that it merits species status under the phylogenetic species concept, and that it is a cryptic species because it lacks obvious morphological autapomorphy.

Experimental pollinations were conducted within and between entities from south-eastern Australia. Fertility was measured as percent seed set. Cross-pollinations between plants of *D. peltata* 'Black Mountain, A.C.T.' from different populations showed a decline in fertility with increasing geographic separation, which indicates outbreeding depression. Self- and cross-pollinations within entities and between entities were similarly highly fertile. Flowers exhibited a delayed autonomous self-pollination mechanism, which would provide reproductive assurance. Stamens inflexed bringing the anthers into contact with the stigmatic surfaces at the end of floral life. This highly selfing breeding system in the *D. peltata* complex would genetically isolate populations and entities within this complex, which would facilitate speciation.

Synthesis of my morphological, molecular and breeding system data indicate that the *D. peltata* complex consists of three species: the narrow endemic *D. bicolor*, the widespread and highly morphologically variable *D. peltata*, and an undescribed cryptic species: *D. peltata* 'Western Australian Form'.

Prologue

Format

The format of this thesis follows that of *Australian Systematic Botany*, except for numbering of the headings, figures and tables. Otherwise the Style Guide of the University of New England (http://www.une.edu.au/tlc/styleguide/) was followed.

The bibliographic style was formatted using Endnote 9 software and with few exceptions, follows the protocol of *Australian Systematic Botany*. The exceptions to the protocol are that:

- figures, plates and tables are located throughout the text
- section headings are numbered
- spaces have been placed between paragraphs

Thesis layout

The body of this thesis is composed of six chapters. A general introduction is presented in Chapter one introducing the species problem, species concepts and the *Drosera peltata* complex. Phenetic and cladistics approaches to resolving species problems and the aims of the thesis are also covered in Chapter one. Chapter two is the phenetic analysis of the morphological data matrix. Chapter three presents a cladistic analysis of *trnL* and ITS genes in examining entities within the *Drosera peltata* complex. The results and interpretation of experimental pollinations between select entities of the *D. peltata* complex is covered in Chapter four. Chapter five explores the results of the three analyses and the history of names applied to members of the complex. Finally, Chapter six provides the general discussion and conclusion for the thesis.

Data availability

Due to the large size of the phenetic matrix and the DELTA dataset, these are presented on CD at the back of this thesis. Additionally, copies are held by me and J.J. Bruhl at Botany, UNE and will be available on request following the publication of the relevant sections.

Acknowledgements

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Without the resources of Botany, in the school of Environmental Sciences and Natural Resource Management, at the University of New England, this project would not have happened. I am grateful for funding for this project from School (UNE), the Noel C. W. Beadle Scholarship, and the Botanic Gardens Trust, Sydney.

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Dr. Mark Whitten, at the University of Florida, at Gainesville, provided a great boost to the project by conducting a pilot study on sequencing genes from a range of entities of the *Drosera peltata* complex that proved to be useful for this project. Dr. Whitten then went on to provide much assistance by sample preparation and sequencing *Drosera* DNA used for this study. The staff at the molecular lab at the University of Florida are thanked.

The directors and staff at K, BM, BR, NE, NSW and UPS are thanked for providing access to specimens and facilities during this project. Accessing many of the type specimens provided a great boost for resolving the classification of the study group. This project would not have happened without discussions with Dr. Neville Marchant, former director of PERTH. From these conversations my interest in the study group developed into the plan for a formal study, led to my contact with Associate Professor Jeremy Bruhl, and the formulation of this PhD project.

During my candidature I have worked full time whilst studying. I am grateful for the help work managers and colleagues have provided during my studies. I am particularly grateful to the enthusiastic help from Steve Lewer in providing me with references.

Last, and by no means least, I could not have completed this project without the support and assistance of my family and friends, in this country and overseas. I am grateful for the assistance from my partner Kirk (Füzzy) Hirsch. He is a wonderful companion in the field; used his horticultural skills at improving the growing conditions for plants used in the experimental pollinations; provided a great sounding board for developing chapters; and greatly improved the quality of many of the figures thanks to his Adobe Photoshop skills.

Whilst my name appears as the author for this document, and I have done the work behind this project, this thesis could not have been done without the help of others. I feel I have learnt much during this apprenticeship, which certainly had more twists and turns than I expected from the outset. For those who I have not named above, but who have provided help along I pass on a big "thank you".

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