



## Seed morphology of bladderworts: a survey on *Utricularia* sect. *Foliosa* and sect. *Psyllosperma* (Lentibulariaceae) with taxonomic implications

CRISTINE GOBBO MENEZES<sup>1\*</sup>, EDUARDO CUSTÓDIO GASPARINO<sup>1</sup>, PAULO CESAR BALEEIRO<sup>2</sup> & VITOR FERNANDES OLIVEIRA DE MIRANDA<sup>1</sup>

<sup>1</sup>Faculdade de Ciências Agrárias e Veterinárias, UNESP—Univ Estadual Paulista, Campus Jaboticabal, Departamento de Biologia Aplicada à Agropecuária, Laboratório de Sistemática Vegetal e Palinologia, Via de Acesso Prof. Paulo Donato Castellane s/n, CEP 14884-900, Jaboticabal, SP, Brazil; e-mail: cristine.menezes@gmail.com

<sup>2</sup>Laboratório de Sistemática Vegetal, Departamento de Botânica, Instituto de Biociências, edifício sobre as ondas, Universidade de São Paulo, Rua do Matão 277, Cidade Universitária, CEP 05508-900, São Paulo, SP, Brazil.

\*Author for correspondence

### Abstract

Species from *Utricularia* sect. *Foliosa* and sect. *Psyllosperma* were studied based on seed characteristics. Our goals were to search for informative characters useful to species delimitations, especially for very polymorphic species such as *U. amethystina*, and also to provide an identification key and discussion about the delimitation of both sections. The qualitative characters of seeds were more useful than quantitative ones for taxonomic purposes but, as presented here in an identification key, it was impossible to distinguish three species from each other (*Utricularia huntii*, *U. praelonga* and *U. tridentata*). Our results are not enough for deep speculations about the delimitation of both sections. However, they do not agree with Taylor's system, because it was impossible to separate the studied species in two clearly different groups. However, the variability found in the seed characters was evaluated in this work and we also briefly discussed the ecologic implications of some seed traits.

**Key words:** dispersion, exalbuminous seeds, morphometry, taxonomy, testa, *Utricularia amethystina*

### Introduction

Lentibulariaceae Richard in Poiteau & Turpin (1808: 23) is a carnivorous plant family whose species usually show diminutive anatropous seeds (Farooq 1964, Shivaramiah 1967, Rajan and Kumar 1973, Corner 1976). Interestingly some lineages within the family lost the cotyledons (Kondo *et al.* 1978, Płachno & Świątek 2009), particularly *Genlisea* Saint-Hilaire (1833: 428) and some species of *Utricularia* Linnaeus (1753: 18), which represents an apomorphic status considering that in the early branching genus *Pinguicula* Linnaeus (1753: 17) (Jobson *et al.* 2003, Müller *et al.* 2004) the cotyledons are present, even if often reduced from two to just one (Degtjareva *et al.* 2004). The embryonic traits in *Pinguicula* are relevant to delimitate infrageneric taxa (Degtjareva *et al.* 2004). Characters from *Genlisea* seeds are also important for infrageneric delimitation: *Genlisea* subgen. *Genlisea*, with pyramidal seeds, and subgen. *Tayloria* (Fromm 1977: 2) Fischer *et al.* (2000: 293), with prismatic, globose or ellipsoidal seeds (Fromm-Trinta 1979, Fleishmann *et al.* 2011, 2012, Fischer *et al.* 2000).

*Utricularia* is the richest and most widespread genus in the family, which also reflects the high morphological diversity of the traps (Taylor 1989, Guisande *et al.* 2007, Reifenrath *et al.* 2006). Different lineages within the genus spread out and adapted to different environments, as the aquatic (free-floating or affixed forms) and terrestrial habitats, assuming also the lithophytic, epiphytic and reophytic forms. As for the traps, seeds of *Utricularia* are also very morphologically variable, especially concerning the form and tegument surface (testa), as noticed and described by different authors (e.g. Abraham & Subramanyan 1965, Taylor 1989). Therefore, if the seeds are as variable as the traps in morphologic traits, also should be useful for the taxonomy within the genus.

Identification key for *Utricularia* sect. *Foliosa* Kamieński and *U.* sect. *Psyllosperma* P.Taylor based on seeds traits

1. Ovate-deltoid seeds; star-shaped testa cells ..... *U. calycifida*
- Seeds not ovate-deltoid; testa cells not star-shaped ..... 2
2. Rounded seeds, elongated or fusiform ..... *U. amethystina*
- Prismatic seeds ..... 3
3. Periclinal walls of testa cells with tuberculous surface ..... *U. hispida*
- Periclinal walls of testa cells with smooth surface ..... 4
4. Testa cells with length/width ratio  $\leq 2$  ..... *U. longifolia*
- Testa cells with length/width ratio  $> 2$  ..... *U. huntii* / *U. praelonga* / *U. tridentata*

## Acknowledgements

We want to sincerely thank Laboratório de Microscopia Eletrônica (Unesp/FCAV) for all logistical support to SEM analyses, and especially technician Cláudia Aparecida Rodrigues for her precious and kind assistance for sample and photo preparation, and also to herbaria HB, INPA, IPA, SPF and UB for loaning the samples. Special thanks to Yoannis Domínguez Rodríguez, Saura Rodrigues da Silva and Luiz Eduardo Mascaro for all the fruitful discussion in our laboratory group. This paper is part of the first author's PhD project supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq grants N. 14884/2012-6), and Unesp/PROPE, Univ Estadual Paulista, Brazil. The samples were collected with the SisBio authorization n. 26938-1 by the Ministério do Meio Ambiente (MMA) and Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio).

## References

- Abraham, V. & Subramnyam, K. (1965) Studies on seeds of various taxa of *Utricularia* occurring in west Bengal. *Botanical Survey of India*, 62: 97–102.
- Benjamin, L. 1847. Lentibulariaceae. *Linnaea*, 20: 485–498.
- Corner, E.J.H. (1976) Lentibulariaceae. In: Corner, E.J.H. (ed.) *The Seeds of Dicotyledons*. Cambridge University Press, Cambridge, pp. 173–174.
- Conti, F. & Peruzzi, L. (2006) *Pinguicula* (Lentibulariaceae) in central Italy: taxonomic study. *Annales Botanici Fennici* 43: 321–337.
- Degtjareva, G., Casper, J., Hellwig, F. & Sokoloff, D. (2004) Seed morphology in the genus *Pinguicula* (Lentibulariaceae) and its relation to taxonomy and phylogeny. *Botanische Jahrbücher* 125: 431–452.  
<http://dx.doi.org/10.1127/0006-8152/2004/0125-0431>
- Eriksson, O. & Kainulainen, K. (2011) The evolutionary ecology of dust seeds. *Perspectives in Plant Ecology, Evolution and Systematics* 13: 73–87. DOI: <http://dx.doi.org/10.1016/j.ppees.2011.02.002>
- Farooq, M. (1964) Studies in Lentibulariaceae - Embriology of *Utricularia stellaris* Linn.f. var. *inflexuosa*. Part 1. Flower, organogeny, ovary, megasporogenesis and female gametophyte. *Proceedings of the National Academy of Sciences of the India* 30: 263–279.
- Fernández-Pérez, A. (1964) Plantas Insetivoras I. Lentibulariaceas de Colombia y Peru. *Caldasia* 9(41): 5–84.
- Fischer E., Porembski S. & Barthlott W. (2000) Revision of the genus *Genlisea* (Lentibulariaceae) in Africa and Madagascar with notes on ecology and phytogeography. *Nordic Journal Botany* 20: 291–318.  
<http://dx.doi.org/10.1111/j.1756-1051.2000.tb00746.x>
- Fleischmann, A., Rivadavia, F., Gonella, P.M. & Heubl, G. (2011) A revision of *Genlisea* subgenus *Tayloria* (Lentibulariaceae). *Phytotaxa* 433: 1–40.
- Fleischmann, A. (2012) *A Monograph of the Genus 'Genlisea'*. Redfern Natural History Productions, Ltd., Poole. 727 pp.
- Fromm-Trinta, E. (1977) *Tayloria* Fromm-Trinta—Nova Seção do gênero *Genlisea* St.-Hil. (Lentibulariaceae). *Boletim do Museu Nacional Rio de Janeiro, Botanica* 44: 1–4.
- Fromm-Trinta, E. (1979) Revisão das espécies do gênero *Genlisea* St.-Hil. (Lentibulariaceae) das regiões sudeste e sul do Brasil. *Rodriguésia* 31: 17–139.
- Gardner, G. (1842) Contributions towards a Flora of Brazil. *London Journal of Botany* 1: 528–545.
- Guisande, C., Granado-Lorencio, C., Andrade-Sossa, C. & Duque, S.R. (2007) Bladderworts. *Functional Plant Science and Biotechnology* 1: 58–68.
- Jobson, R.W., Playford, J., Cameron, K.M. & Albert, V.A. (2003) Molecular phylogenetics of Lentibulariaceae inferred from plastid *rps16* intron and *trnL-F* DNA sequences: implications for character evolution and biogeography. *Systematic*

*Botany* 28: 157–171.

- Kamiński, F. (1891) Lentibulariaceae. In: Engler, A. & Prantl, K.A.E, *Die Naturalischen Pflanzenfamilien*. W. Engelmann, IV, 3b, (preprint), Leipzig, 108–123.
- Kondo, K., Segawa, M. & Nehira, K. (1978) Anatomical Studies on Seeds and Seedlings of Some *Utricularia* (Lentibulariaceae). *Brittonia* 30: 89–95.  
<http://dx.doi.org/10.2307/2806465>
- Lamarck, J.B.A.P. de M. (1791) *Tableau encyclopedique et methodique des trois règnes de la nature: Botanique* 1. Panckoucke, Paris, 250 pp.  
<http://dx.doi.org/10.5962/bhl.title.218>
- Linnaeus, C. (1753) *Species Plantarum* 1. Impensis Laurentii Salvii, Holmiae, 560 pp.
- Miranda, V.F.O. de & Rivadavia, F. (2010) Lentibulariaceae. In: Forzza, R.C., Baumgratz, J.F.A., Bicudo, C.E.M., Jr., A.A.C., Costa, A., Costa, D.P., Hopkins, M., Leitman, P.M., Lohmann, L.G., Maia, L.C., Martinelli, G., Menezes, M., Morim, M.P., Coelho, M.A.N., Peixoto, A.L., Pirani, J.R., Prado, J., Queiroz, L.P., Souza, V.C., Stehmann, J.R., Sylvestre, L.S., Walter, B.M.T. & Zappi, D. (eds.) *Catálogo de Plantas e Fungos do Brasil* 2(1). Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro, pp. 1163–1166.
- Miranda, V.F.O. de & Rivadavia, F. (2013) Lista de Espécies da Flora do Brasil: Lentibulariaceae. Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro. Available from: <http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB146> (accessed: 10 June 2013).
- Müller, K., Borsch, T., Legendre, L., Porembski, S., Theisen, I. & Barthlott, W. (2004) Evolution of carnivory in Lentibulariaceae and the Lamiales. *Plant Biology* 6: 1–14.  
<http://dx.doi.org/10.1055/s-2004-817909>
- Müller, K. & Borsch, T. (2005) Phylogenetics of *Utricularia* (Lentibulariaceae) and molecular evolution of the *trnK* intron in a lineage with high substitutional rates. *Plant Systematics and Evolution* 250: 39–67.  
<http://dx.doi.org/10.1007/s00606-004-0224-1>
- Płachno, B. & Świątek, P. (2009) Unusual embryo structure in viviparous *Utricularia nelumbifolia*, with remarks on embryo evolution in genus *Utricularia*. *Protoplasma* 239: 69–80.  
<http://dx.doi.org/10.1007/s00709-009-0084-1>
- Rajan, S.S. & Kumar, D.J. (1973) Embryological studies in Lentibulariaceae. I. Floral morphology and embryology of *Utricularia smithiana*. *Proceedings of the National Academy of Sciences* 80: 18–25.
- Reifenrath, K., Theisen, I., Schnitzler, J., Porembski, S. & Barthlott, W. (2006) Trap architecture in carnivorous *Utricularia* (Lentibulariaceae). *Flora* 201: 597–605.  
<http://dx.doi.org/10.1016/j.flora.2005.12.004>
- Richard, L.C.M. (1808) Lentibulariae. In: Poiteau, P.A. & Turpin, P.J.F. *Flore parisienne: contenant la description des plantes qui croissent naturellement aux environs de Paris* 1. PR, Paris, pp. 26.
- Saint-Hilaire, A.F.C. de. (1833) *Voyage dans le District des Diamans du Brésil*. Librairie-Gide, Paris, 454 pp.
- Saint-Hilaire, A. & Girard, F. de. (1838) Monographie des Primulacées et des Lentibulariées du Brésil méridional. *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences* 7: 868–870.
- Shivaramiah, G. (1967) Observations on the floral morphology and embryology of *Utricularia stricticaulis* Stapf. *Proceedings of the National Academy of Sciences* 65: 56–62.
- Sylvén, N.O.V. (1909) Die Genliseen und Utricularien des Regnellischen Herbariums. *Arkiv für Botanik* 8: 1–48 pp.
- Taylor, P. (1986) New Taxa in *Utricularia* (Lentibulariaceae). *Kew Bulletin* 41: 8–9.
- Taylor, P. (1989) *The Genus Utricularia—a taxonomic monograph*. *Kew Bulletin Additional Series* 14: 724 pp.
- Zamudio, S. & Olvera, M. (2009) A new species of *Utricularia* (Lentibulariaceae) from Guerrero, Mexico. *Brittonia* 61: 119–125.  
<http://dx.doi.org/10.1007/s12228-008-9063-7>.