



University
of Victoria

Graduate Studies

PROGRAMME

REVISED

The Final Oral Examination
for the Degree of

DOCTOR OF PHILOSOPHY
(Department of Biology)

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2010	University of Victoria	MSc (Biology)
2008	University of Victoria	BSc (Biology)

“Proteins in gymnosperm pollination drops.”

Friday, December 5, 2014

9.15am

Harry Hickman Building, room 120

Supervisory Committee:

Dr. Patrick von Aderkas, Department of Biology, UVic (Supervisor)
Dr. Gerry Allen, Department of Biology, UVic (Member)
Dr. Ben Koop, Department of Biology, UVic (Member)
Dr. Terry Pearson, Department of Biochemistry and Microbiology,
UVic (Outside Member)

External Examiner:

Dr. Sean Graham, Department of Botany
University of British Columbia

Chair of Oral Examination:

Dr. Michael Hayes,
School of Public Health and Social Policy, UVic

Abstract

Most gymnosperms produce a pollination drop that captures and transports pollen into the ovule. Pollination drops have other functions. These include influencing pollen germination and pollen tube growth, defending the ovule from pathogens and providing a food reward in insect-pollinated gymnosperms. Mineral and organic molecules, including proteins, are responsible for these additional functions. To date, pollination drops from a handful of conifers and one non-conifer gymnosperm, *Welwitschia mirabilis*, have been subjected to proteomic analysis. In the present study, tandem mass spectrometry was used to detect proteins in all gymnosperm lineages: cycads (*Ceratozamia hildae*, *Cycas rumphii*, *Zamia furfuracea*); Gnetales (*Ephedra compacta*, *E. distachya*, *E. foeminea*, *E. likiangensis*, *E. minuta*, *E. monosperma*, *E. trifurca*; *Gnetum gnemon*; *Welwitschia mirabilis*); *Ginkgo biloba*; conifers (*Taxus x media*). PEAKS 6 DB (Bioinformatics Solutions, Waterloo, ON, Canada) was used to make protein identifications. Proteins were detected in all gymnosperm species analyzed. The numbers of proteins identified varied between samples as follows: one protein in *Welwitschia* female; nine proteins in *Cycas rumphii*; 13 proteins on average in *Ephedra* spp.; 17 proteins in *Gnetum gnemon*; 38 proteins on average in *Zamia furfuracea*; 57 proteins in *Ginkgo biloba*; 61 proteins in *Ceratozamia hildae*; 63 in *Taxus x media*; 138 proteins in *Welwitschia* male. The types of proteins identified varied widely. Proteins involved in carbohydrate modification, e.g. galactosidase, chitinase, glycosyl hydrolase, glucosidase, were present in most gymnosperms. Similarly, defense proteins, e.g. reduction-oxidation proteins, lipid-transfer proteins, thaumatin-like proteins, were identified in many gymnosperms. Gymnosperms that develop a deep pollen chamber as the nucellus degrades, e.g., cycads, *Ginkgo*, *Ephedra*, generally contained higher proportions of proteins localized to intracellular spaces. These proteins represent the pollination drop degradome. Gymnosperms that either lack a pollen chamber, e.g. *Taxus*, or have a shallow pollen chamber, e.g. *Gnetum*, had greater proportions of extracellular proteins. These proteins represent the pollination drop secretome. Our proteomic analyses support the hypothesis that the pollination drops of all extant gymnosperms constitute complex reproductive secretions.

Awards, Scholarships, Fellowships

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2010 President's Research Scholarship, UVic
2010-2012 NSERC PGS D
2009 President's Research Scholarship, UVic
2009 National Tropical Botanical Garden Award to attend Harvard University Summer School
2009 NSERC PGS M Extension
2008 President's Research Scholarship, UVic
2008 NSERC CGS M
2008 M.C. Melburn Award, UVic
2008 NSERC USRA (declined)
2007 President's Scholarship, UVic
2006 President's Scholarship, UVic
2005 President's Scholarship, UVic
2004 President's Scholarship, UVic
2003 President's Scholarship, UVic

Presentations

1. Prior, N. "*Proteins in the pollination drops of cycads*" Montgomery Botanical Center Lecture Series, Coral Gables, Florida, USA. February 2014 (guest lecture)
2. Prior, N.; Little, S., Boyes, I., Smith, D., Hardie, D., Griffith, M.P., Stevenson, D.W. and von Aderkas, P. "*Understanding gymnosperm pollination drop proteins with RNA-Seq transcriptome data*" Botany 2013 (Botanical Society of America), New Orleans, Louisiana, USA. August 2013 (poster)
3. von Aderkas, P.; Lunny, A.; Little, S.; Prior, N. "*Conifer pollination mechanisms revisited.*" Workshop on Reproductive Biology, Surrey, British Columbia, Canada. July 2013 (oral)
4. Prior, N.; Han, J.; Hardie, D.; Smith, D.; von Aderkas, P. "*Pollination drops in cycads.*" Botany 2012 (Botanical Society of America), Columbus, Ohio, USA. July 2012 (poster)
5. Pirone, C.; von Aderkas, P.; Prior, N.; Smith, D.; Hardie, D.; Tomlinson, P.B.; Friedman, N.; Mathews, S. "*Proteins in the pollination drop of two species of Cephalotaxus.*" Botany 2012 (Botanical Society of America), Columbus, Ohio, USA. July 2012 (poster)

6. von Aderkas, P.; Little, S.; Pirone, C.; Cross, T.; Hardie, D.; Smith, D.; Han, J.; Jesse, S.; Prior, N.; Thornburg, R.; Bolinder, K.; Hou, C.; Ickert-Bond, S.M.; Borchers, C.; Rydin, C. "*Degradome and proteome of pollination drops of Ephedra and other gymnosperms (Gnetidae, Ginkgoideae and Pinidae).*" Botany 2012 (Botanical Society of America), Columbus, Ohio, USA. July 2012 (oral)
7. Hou, C.; Prior, N.; Bolinder, K.; Rydin, C.; von Aderkas, P. "*Proteome of pollination drops of four species of Ephedra (Gnetales).*" Botany 2012 (Botanical Society of America), Columbus, Ohio, USA. July 2012 (poster)
8. von Aderkas, P.; Coulter, A.; Hardie, D.; Prior, N. "*Culturing nucellus as a way to produce proteins involved in conifer reproduction.*" International Union of Forest Research Organizations Working Party: Somatic Embryogenesis and Other Vegetative Propagation Technologies, Brno, Czech Republic. June 2012 (oral)
9. von Aderkas, P.; Gill, J.; Ohlund, L.; Hutchison, S.; Prior, N.; Hensel, J.; Clemis, L.; Smith, D.; Coulter, A.; Borchers, C.; Horgan, K. "Towards MALDI-TOF/TOF imaging of single plant egg cells." Biochemical Society Meeting, Bath, UK. September 2009 (poster)

Publications

1. *Prior, N.; Little, S.A.; Pirone, C.; Gill, J.E.; Smith, D.; Han, J.; Hardie, D.; O'Leary, S.J.B.; Wagner, R.E.; Cross, T.; Coulter, A.C.; Borchers, C.; Olafson, R.W.; von Aderkas, P.; **"Application of proteomics to the study of pollination drops." *Applications in Plant Sciences* **2013**, *1*, DOI <http://dx.doi.org/10.3732/apps.1300008>.
2. von Aderkas, P.; * Prior, N.; Jesse, S.; Little, S.; Cross, T.; Hardie, D.; Borchers, C.; Thornburg, R.; Hou, C.; Lunny, A.; **"Degradome and secretome of pollination drops of *Ephedra*." In Press, Botanical Review 2014.
3. Little, S.A.;* Prior, N.; Pirone, C.; von Aderkas, P.; **"Pollen-ovule interactions in gymnosperms." In K. Ramawat and JMM Merillon (eds.), *Reproductive biology of plants*. CRC Press, New York.