

ABSTRACT

The economic, sociological and biological value of our forests makes their sustainability essential to our well-being. To ensure their long-term health, it is critical to regularly and effectively monitor their inhabitants, as well as to detect non-indigenous species early and accurately. These programs rely on the precise diagnosis of species, which can be complicated for terrestrial arthropods by sizeable trap samples, damaged specimens, immature life stages and incomplete taxonomy. The recent advent of DNA barcoding, a technique that differentiates species using sequence variation in a standard gene region, shows tremendous promise for circumventing these obstacles. This dissertation evaluates the integration of barcoding into forest arthropod biomonitoring and biosurveillance programs with several investigations of nocturnal moths (Lepidoptera) in British Columbia, Canada. Barcode reference libraries are constructed for looper moths (Geometridae) and *Lymantria* (Lymantriinae) tussock moths, and are determined to successfully discriminate species in over 93% and 94% of cases, respectively. The libraries demonstrate how barcoding might enhance biosurveillance programs by flagging two new records for geometrid moths, and by successfully diagnosing 32 intercepted tussock moth specimens. These two libraries, and a multi-gene phylogeny constructed for Geometridae, are used to conduct faunal inventories in modified forest systems, and investigate the influence of disturbance on three levels of moth diversity—species, genetic, and phylogenetic. A first level inventory of Stanley Park, Vancouver, produces a preliminary list of 190 species, the detection of four new exotic species, and the discovery of two potentially cryptic species. Surveys conducted across several harvest treatments at two silvicultural research forests display no evidence of increased diversity at intermediate disturbance levels, but do reveal a correlation between species and genetic diversity. And lastly, three levels of moth diversity are estimated in ponderosa pine systems that differ widely in attack by *Dendroctonus* bark beetles, and demonstrate a negative association between species diversity and tree mortality. In combination, all projects suggest that DNA barcoding provides several advantages over traditional biosurveillance and biomonitoring, including the ability to rapidly sort specimens, a reduction in specialist time, the detection of species at low density, and the ability to appraise multiple levels of diversity.

BIOGRAPHICAL NOTES

Born: January 9, 1977, Brantford, Ontario

Academic Studies: B. Sc. University of Guelph, 2000
M. Sc. University of Guelph, 2004

GRADUATE STUDIES

Field of Study: Molecular Biodiversity

Courses

CONS 501 Topics in Conservation Genetics

Instructors

Drs. S. Aitken & E. Taylor

SELECTED AWARDS

2010 UBC Mary and David Macaree Fellowship
2010 UBC Wright Scholarship in Forestry
2009 – 2010 UBC Pacific Century Graduate Scholarship
2009 Entomological Society of BC James Grant Award
2009 NSERC Michael Smith Foreign Study Supplement
2008 – 2010 Pacific Forestry Centre Graduate Student Award
2007 – 2009 Forest Investment Account – FSP Student Grant
2007 – 2008 NSERC RBCM Systematics Research Graduate Supplement
2006 – 2009 NSERC Canada Graduate Scholarship (CGS D3)

SELECTED PUBLICATIONS

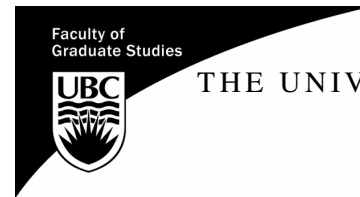
deWaard, J.R., Hebert, P.D.N., and Humble, L.M. A comprehensive DNA barcode library for the looper moths (Lepidoptera: Geometridae) of British Columbia, Canada. PLoS ONE. *In press*.

deWaard, J.R., Humble, L.M., and Schmidt, B.C.S. DNA barcoding identifies the first North American records of the Eurasian moth, *Eupithecia pusillata* (Lepidoptera: Geometridae). Journal of the Entomological Society of BC. *In press*.

deWaard, J.R., Mitchell, A., Keena, M.A., Gopurenko, D., Boykin, L.M., Armstrong, K.F., Pogue, M.G., Lima, J., Floyd, R., Hanner, R.H. and Humble, L.M. Towards a global barcode library for *Lymantria* (Lepidoptera: Lymantriinae) tussock moths of biosecurity concern. PLoS ONE. *In press*.

Floyd, R., Lima, J., deWaard, J.R., Humble, L.M. and Hanner, R.H. (2010). Common goals: incorporating DNA barcoding into international protocols for identification of arthropod pests. Biological Invasions 12: 2947–2954.

Hebert, P.D.N., deWaard, J.R., and Landry, J.-F. (2010). DNA barcodes for 1/1000 of the Animal Kingdom. Biology Letters 6: 359–362.



deWaard, J.R., Landry, J.-F., Schmidt, B.C., Derhousoff, J., McLean, J.A. and Humble, L.M. (2009). In the dark in a large urban park: DNA barcodes illuminate cryptic and introduced moth species. *Biodiversity and Conservation* 18: 3825–3839.

deWaard, J.R., Schmidt, B.C., Anweiler, G.G., and Humble, L.M. (2008). First Canadian records of *Lampropteryx suffumata* ([Denis & Schiffermüller], 1775) (Geometridae: Larentiinae). *Journal of the Entomological Society of BC* 105: 19–25.

deWaard, J.R., Ivanova, N.V., Hajibabaei, M. and Hebert, P.D.N. (2008). Assembling DNA Barcodes: Analytical Protocols. In *Methods in Molecular Biology: Environmental Genetics* (Ed: Cristofre Martin; Humana Press Inc., Totowa, USA). Pp. 275-293.

deWaard, J.R., Sacherova, V., Cristescu, M.E.A., Remigio, E.A., Crease, T.J., and Hebert, P.D.N. (2006). Probing the origins of the branchiopod crustaceans. *Molecular Phylogenetics and Evolution* 39: 491–502.

Hebert, P.D.N., Cywinska, A., Ball, S.L., and deWaard, J.R. (2003). Biological identifications through DNA barcodes. *Proceedings of the Royal Society of London B* 270: 313–321.

SELECTED PRESENTATIONS

deWaard, J.R., Landry, J.-F., and Humble, L.M. Molecular phylogenies and DNA barcodes: tools for forest biodiversity science. The Annual Meeting of the Entomological Society of Canada. Vancouver, BC. November 2, 2010.

deWaard, J.R., Mitter, C., Hausmann, A., and Humble, L.M. “The ‘barcode approach’ to combining molecular datasets: Reconstructing the phylogeny of North America’s Geometridae as an example”. Forum Herbulot. Gainesville, Florida. June 22, 2010.

deWaard, J.R. and Humble, L.M. “Forest Biomonitoring, biosecurity and DNA barcoding”. Third International Conference for the Barcoding of Life. Mexico City, Mexico. November 12, 2009.

deWaard, J.R. and Humble, L.M. “Forest Biosecurity and DNA barcoding”. IUFRO International Forest Biosecurity Conference. Rotorua, New Zealand. March 19, 2009.

deWaard, J.R. and Humble, L.M. “DNA barcodes and monitoring forest health”. Forum Herbulot. Munich, Germany. June 25, 2008.

SUPERVISORY COMMITTEE

Dr. Leland Humble (Forest Sciences)
Dr. Yousry El-Kassaby (Forest Sciences)
Dr. John McLean (Forest Sciences)

PROGRAMME

The Final Oral Examination
For the Degree of

DOCTOR OF PHILOSOPHY
(Forest Sciences)

JEREMY R. DEWAARD

B. Sc. University of Guelph, 2000
M. Sc. University of Guelph, 2004

Thursday, December 16, 2010, 9:00 am
Theatre, Centre for Teaching, Learning and Technology
University Services Building

“Forest Biomonitoring, Biosecurity and DNA Barcoding”

EXAMINING COMMITTEE

Chair:
Dr. Dixie Mager (Medical Genetics)

Supervisory Committee:
Dr. Leland Humble, Research Supervisor (Forest Sciences)
Dr. Yousry El-Kassaby, Academic Supervisor (Forest Sciences) –
(attending remotely)

University Examiners:
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Dr. Richard Hamelin (Forest Sciences)

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