Experimental and theoretical approaches to study plant reproductive diversity

University of Campinas, São Paulo, Brazil.
20-22 March, 2017

Mario Vallejo-Marín

Summary

The goal of this course is to provide students with a general overview and basic understanding of some of the methods and approaches available to study plant reproductive diversity. I will focus on some of the less studied and most challenging aspects of studying reproductive diversity. In the first day we will focus on experimental studies on **buzz-pollination**, a widespread but little known pollination system in which bees use high frequency vibrations to extract pollen. In the second day, we will talk about **plants that combine sexual and asexual reproductive modes**. We will discuss the challenges of measuring fitness in perennial, clonal plants, and provide some theoretical and statistical tools developed for studying clonal populations. Finally, in the third day we will focus on **estimating male reproductive success via male function**. Although most flowering plants are hermaphrodites, male components of fitness are rarely considered, in part because they are hard to measure. Here we will explain some of the approaches (experimental and theoretical) available to study male fitness.

The course will be delivered through a mix of lectures, discussion groups, data collection in the field, and computer exercises.

1) **Experimental approaches: A case study with buzz-pollination**[1-3]
    a. Floral adaptations to buzz-pollination
    b. Pollinator behaviour and learning
    c. Analysis of vibrations
2) **Sexual vs. asexual strategies**[4-6]
    a. Reproductive allocation trade-offs
    b. Asexual strategies: What is fitness and how to measure it?
    c. Challenges to measure fitness in perennial, clonal plants
    d. Life-table response experiments
3) **Estimating reproductive success via male function**[7,8]
    a. Indirect approaches: pollen dyes, flower number
    b. Genetic approaches: phenotypic markers,
    c. Genetic approaches: paternity analysis

Seminar

Hybridisation and speciation under global change

Schedule

Monday 20th March	**Buzz-pollination**		***You need:***
9:00am	**Lecture: Buzz-pollination**	Introduction	
		Methods (theory)	
10:00am	**Computer practical**	Using Audacity	*Computer with Audacity installed*
		Machine Learning	*Practical Handouts*
11:00am	**Field exercise**	Collect bee buzzes	*Audio recorder; plastic vials, entomological net, field notes*
		Analyse buzzes using Audacity	*Computer*
2:00pm	**Lunch break**		
4:00pm	**Paper discussion**	Bee learning. Morgan et al. (2016)	*Read paper in advance*
5:00pm	**Round table discussion**	What is learning? How to experimentally study pollinator learning?	*Background reading on insect learning would recommended.*

Tuesday 21th March	**Fitness in clonal plants**		***You need:***
9:00am	**Lecture: Clonal reproduction**	Introduction	
		Effect of clonality on sexual strategies	
10:00am	**Paper discussion**	Fitness in clonal organisms. Pan and Price (2001)	*Read paper in advance*
11:00am	**Lecture: Demographic approaches to fitness**	Measuring fitness in clonal plants using population matrices	
1:00pm	**Practical: Estimating clonal fitness**	Case study using clonal monkeyflowers	*Computer with: R, RStudio, popbio*
		Using the program *popbio*	
2:00pm	**Lunch break**		
4:00pm	**Group miniproject**	Analysis of demography using COMPADRE	*Computer with R, internet access.*

		Literature review of measuring fitness in clonal plants	
5:00pm	**(Optional) Using *R*, *RStudio***	Using *RStudio* to organise statistical analyses in *R*	*Computer, RStudio*

Wednesday 22th March	**Estimating male fitness**		***You need:***
9:00am	**Lecture: Fitness in hermaphrodites, mating system**	Introduction	
		Estimating outcrossing rates	
10:00am	**Lecture: Estimating paternity**	Parentage analysis	
		Maximum likelihood and Bayesian approaches	
11:00am	**Field exercise: Pollen flow using dyes**	Use dyes to distinguish self- vs. cross-pollen	*Fluorescent dyes (provided), UV lamp (provided), entomological net, dissecting microscope, plastic vials, ice, ice-container. Flowers, bees, flies.*
		Use dyes to detect safe-sites on pollinators bodies	
2:00pm	**Lunch break**		
3:00pm	**Paper discussion**	Parentage analysis. Jones et al. (2009)	*Read paper in advance*
4:00pm	**Round table: Future challenges to measure plant paternity**		*Computer, internet access*
5:00pm	**(Optional) Reproducible research: Primer on using *RMarkdown***	Using the program *RStudio* to generate ***RMarkdown*** documents	*Computer, RStudio*

Bibliography

1 De Luca, P. A. & Vallejo-Marín, M. What's the 'buzz'about? The ecology and evolutionary significance of buzz-pollination. *Current opinion in plant biology* **16**, 429-435 (2013).

2 Buchmann, S. L. in *Handbook of Experimental Pollination Biology* (eds C. E. Jones & R. J. Little) 73-113 (Scientific and Academic Editions, 1983).

3 Harder, L. D. & Barclay, R. M. R. The functional significance of poricidal anthers and buzz pollination: Controlled pollen removal from Dodecatheon. *Functional Ecology* **8**, 509-517 (1994).

4 Vallejo-Marin, M., Dorken, M. E. & Barrett, S. C. H. The Ecological and Evolutionary Consequences of Clonality for Plant Mating. *Annual Review of Ecology Evolution and Systematics* **41**, 193-213, doi:10.1146/annurev.ecolsys.110308.120258 (2010).

5 Pan, J. J. & Price, J. S. Fitness and evolution in clonal plants: the impact of clonal growth. *Evolutionary Ecology* **15**, 583-600 (2001).

6 Peterson, M. L., Kay, K. M. & Angert, A. L. The scale of local adaptation in Mimulus guttatus: comparing life history races, ecotypes, and populations. *New Phytol* **211**, 345-356, doi:10.1111/nph.13971 (2016).

7 Jones, A. G., Small, C. M., Paczolt, K. A. & Ratterman, N. L. A practical guide to methods of parentage analysis. *Mol Ecol Resour* **10**, 6-30, doi:10.1111/j.1755-0998.2009.02778.x (2010).

8 Jones, A. G. & Ardren, W. R. Methods of parentage analysis in natural populations. *Mol Ecol* **12**, 2511-2523 (2003).