A Primer of Ecological Genetics

Jeffrey K. Conner
Michigan State University

Daniel L. Hartl
Harvard University
Contents

Preface ix
Acronyms, Abbreviations, and Symbols xiii

1 Introduction 1
What is Ecological Genetics? 1
Overview of the Book 3
Basic Genetic Terms 4

2 Population genetics I: Genetic variation, random and nonrandom mating 9
What is Population Genetics? 9
What are populations and why are they important? 9
Genetic Variation 11
Measuring Genetic Variation: Genetic Markers 12
Visible polymorphisms 13
Molecular markers 13
Protein electrophoresis 14
DNA markers 16
Measuring Genetic Variation: Simple Summary Statistics 22
Organization of Genetic Variation within Populations 24
Random mating 25
Assumptions of the Hardy-Weinberg model 25

Box 2.1 What Is a Model? 26

Deriving the Hardy-Weinberg equations 27

Uses of the Hardy-Weinberg Model: Tests for Departure from HWE 31

Box 2.2 A Brief Introduction to Statistics 32

Recessive alleles hidden in heterozygotes 35

Nonrandom Mating 36

Assortative mating 36

Inbreeding 37

Problems 43

Suggested Readings 44

Chapter References 44

3 Population genetics II: Changes in allele frequency 47

Mutation 47

Migration 48

Genetic Drift 52

Random genetic drift 52

Population differentiation 55

F-statistics 57

Box 3.1 Calculation of F-statistics 60

Effective population size (N_e) 62

Inbreeding with random mating in small populations 65

Natural Selection: Selection on Genotypes 66

Box 3.2 Example of Inbreeding Depression Due to Genetic Drift 66

Fitness 67

How does selection at one locus change allele frequencies at that locus? 69

Overdominance or heterozygote advantage 71

Frequency dependent selection 76

Population Genetics: Synthesis 77

Interactions Between the Four Evolutionary Forces 79

Mutation–selection balance 79

Selection vs. migration 81

Selection vs. genetic drift 81

Migration vs. genetic drift 84

Methods of measuring gene flow 85

Selection, genetic drift, and gene flow: Wright’s shifting balance theory 86
4 Quantitative genetics I: Genetic variation 97

Mendelian Basis of Continuous Traits 97
Different types of gene action 103
How can we quantify gene action? 104
Population mean 106
Population variance 108
Breeding value 111
Heritability 112
Estimating Additive Variance and Heritability 115
Offspring–parent regression 116
Box 4.1 Regression details 118
Maternal and paternal effects 120
Sibling analyses 121
Box 4.2 Analysis of Variance (ANOVA) 122
Comparison of methods 131

Problems 133
Suggested Readings 134
Suggested Readings Questions 134
Chapter References 135

5 Quantitative genetics II: Advanced topics 137

Phenotypic Plasticity and Genotype-by-Environment Interaction 138
Box 5.1 Two-Way ANOVA 141
Multiple Subpopulations—Differentiation vs. Adaptive Plasticity 145
Correlations Among Traits 150
Sources of genetic covariance among traits 155
What can cause linkage disequilibrium? 160
Mechanisms of genetic correlations in nature 160
Artificial Selection 163
Advantages and disadvantages of artificial selection 169
QTL Mapping 170
Problems 180
Suggested Readings 183
6 Natural selection on phenotypes 189

The Chicago School Approach to Phenotypic Evolution 191
Selective Agents and Targets 196
  Multiple traits; direct and indirect selection 199
  Selection gradients 200
  Experimental manipulation 205
  Correlational selection 208
  How do we study selective agents? 211
Notes on the Study of Adaptation 215
Synthesis: Predicting Short-Term Phenotypic Evolution 216
  Box 6.1 Summary of Bivariate Relationships in Ecological Genetics 217
The Future of Ecological Genetics 223
Problems 224
Suggested Readings 226
Suggested Readings Questions 227
Chapter References 229

7 Applied ecological genetics 231

Conservation Genetics 232
  What is the unit to be conserved? 233
  How do genetic factors directly affect extinction risk? 235
  Adaptation to environmental change in the future 241
  Conservation genetics in the future 244
Evolution of Invasive Species 245
Transgene Escape 248
  Establishment of transgenes in wild populations 250
  Fitness effects of transgenes 250
  Strategies to reduce transgene escape risk 252
Evolution of Resistance to Pesticides and Antibiotics 253
  Selection 254
  Genetic variance and covariance 257
  Gene flow and population structure 259
  Resistance management 260