

Module 1: Basic Principles in Population and Quantitative Genetics

Introduction

This module serves two purposes. The first is to introduce the goals, organization, and general content of this week-long workshop. The second goal is to introduce basic principles in population and quantitative genetics. Population genetics describes relationships between allele and genotype frequencies illustrates frequency shifts due to evolutionary forces such as migration, mutation, drift, and selection. Quantitative genetics describes the connection between genotype and phenotype and provides tools to illustrate how phenotypic selection changes allele frequencies. Molecular breeding is based in both of these disciplines, so materials introduced in this module are the foundation for all subsequent modules.

Key Messages

- Allele and genotype frequencies are easily related one to the other when populations are unaffected by evolutionary forces, sampling errors are inconsequential, and mating is at random. Such an idealized population is said to be in Hardy-Weinberg equilibrium (HWE).
- Evolutionary forces affecting allele frequencies include mutation, migration, selection, and drift.
- Shifts away from HWE conditions result in predictable shifts in genotype and/or allele frequencies.
- Heritability measures the association of genotype and phenotype, estimated using a statistical parameter known as variance.
- Variance estimates can be obtained in a variety of ways, e.g. from allele or genotype frequencies, or by measuring phenotypes.
- Phenotypic variance can be partitioned into various types of causal components, such as genetic and environmental, and each of these can be further subdivided.

Outcomes

Course attendees will:

- have a better understanding of the historical context of population and quantitative genetics as related to other areas of genetics
- learn how population and quantitative genetics, as basic sciences, are useful in applied fields such as plant and animal breeding, conservation genetics, and human genetics
- have the ability to analyze, manipulate, and interpret, a variety of allelic, genotypic, and phenotypic data
- will gain familiarity with several analytical software packages
- develop a framework of theoretical concepts upon which subsequent applications (e.g. breeding, gene resource management) can be built

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Outline

- I) Workshop Introduction and Overview
 - A) Overall goals and structure for the week
 - B) Introduce participants and instructors (group exercise).
 - C) Workshop philosophy, approach, and content

- II) Overview of genetic approaches
 - A) Historical perspective and key developments
 - B) Interplay of various genetic approaches / pursuits, e.g.:
 - 1) Classical and transmission genetics
 - 2) Quantitative genetics
 - 3) Population genetics
 - 4) Molecular / evolutionary genetics
 - 5) Applied: Human genetics, Conservation genetics, Applied breeding
 - 6) Other fields: statistics, computational biology, computer science
 - C) Forest genetics and sources of variation

- III) Overview of population genetics
 - A) How is pop gen useful?
 - B) Theoretical vs. empirical approaches and data
 - C) Predicting behavior of *individual* genes in populations.
 - 1) Gene/allele frequencies vs. genotype frequencies
 - 2) How allele frequencies change: selection, migration, mutation, drift

- IV) Overview of quantitative genetics
 - A) How is QGen useful?
 - B) Historical context: Mendelians vs. biometricians
 - C) Quantitative phenotypes: multiple (to many) genes affecting a trait. How?
 - 1) Measuring quantitative traits—statistical approaches
 - 2) Mean and variance
 - 3) Partitioning variance $P = G + E$
 - 4) Variance components and their estimation
 - 5) Interpreting and using genetic variation

- V) Lab (Several options, so will likely have several concurrently).
 - A) Packages: Arlequin, Populus (UMinn)
 - B) Topical spreadsheets (custom-built??), illustrating: Wahlund effect; LD calculations (crosses vs. random mating); ANOVA and estimating variance components
 - C) Tutorial assistance (with instructors)