University of New England

Population Genetics

Lecture 4

Applied Animal and Plant Breeding

GENE 251/351

School of Environment and Rural Science (Genetics)

Key issues

- Differences in allele frequencies are a major source of variation between populations

- The frequency of different alleles change due to migration, selection and chance (drift)

- Allele frequencies can be used to define a population and predict results of matings – *but mainly for single locus traits*

- Most traits of interest to animal and plant breeders are quantitative traits.

Genetic Diversity

- Genetic diversity is essential if any organism is going to have the capacity to evolve.

- In plant and animal breeding we are interested in defining and measuring diversity and then managing and manipulating that diversity for specific purposes.

Predicting the outcomes of one specific mating

Mating 1 specific male (heterozygous)
with one specific female (heterozygous)

		50%	50%
		B	b
50%	B	BB Black 25%	Bb Black 25%
50%	b	Bb Black 25%	bb Brown 25%

Punnett Square

- Genotype summary ¼ BB :½ Bb :¼ bb
- Phenotype summary ¾ Black dogs : ¼ Brown dogs

Predicting a whole bunch of matings in a population

Mating 1 specific male (heterozygous)
with a whole bunch of females

Population allele frequencies

Freq (B) = 0.3
Freq(b)= 0.7

		50%	50%
		B	b
30%	B	BB Black 15%	Bb Black 15%
70%	b	Bb Black 35%	bb Brown 35%

Punnett Square

- Genotype summary 15% BB : 50% Bb : 35% bb
- Phenotype summary 65% Black dogs : 35% Brown dogs

Predicting outcome whole bunch of matings in a population

Mating a bunch of males
with a whole bunch of females

Population allele frequencies

Freq (B) = 0.3
Freq(b)= 0.7

		30%	70%
		B	b
30%	B	BB Black 9%	Bb Black 21%
70%	b	Bb Black 21%	bb Brown 49%

Punnett Square

- Genotype summary 9% BB : 42% Bb : 49% bb
- Phenotype summary 51% Black dogs : 49% Brown dogs

Genetic Variation

Hardy Weinberg Equilibrium:

If you know allele frequencies in parents are freq(A) = p and freq(a) = q

Then genotype frequencies in progeny are:

AA	p^2
Aa	$2pq$
Aa	q^2

if random mating,

constant over generations

Example: coat colour in horse

One locus model

- Observe variation: Genotype frequencies
- Infer: Allele frequencies
- Predict progeny: Genotype frequencies

Chestnut	DD	50%
Palomino	Dd	20%
Cremello	dd	30%

allele frequency *freq(D) = (2*50 + 20)/ (2*100) = 0.60*

- What is expected distribution of genotypes under HW?
- What is the expected genotype frequency in the offspring after random mating?
- Describe the expected offspring of a Palomino!

Polygenic model: Quantitative Genetics

- Observe that most traits have continuous variation, i.e. not observed in classes

- Genetic variability for such traits can be explained by the action of many genes

- No specific loci/genes considered
- From one gene to many genes → polygenic model

- From discontinuous to continuous variation

From one locus to many loci

1 locus

A_1A_1	A_1A_2	A_2A_2
−1	0	1

2 loci

		A_1A_1	A_1A_2	A_2A_2
		-1	0	1
B_1B_1	-1	-2	-1	0
B_1B_2	0	-1	0	1
B_2B_2	1	0	1	2

Lots of loci/alleles

From one locus to many loci

1 locus

A_1A_1	A_1A_2	A_2A_2
−1	0	1

2 loci

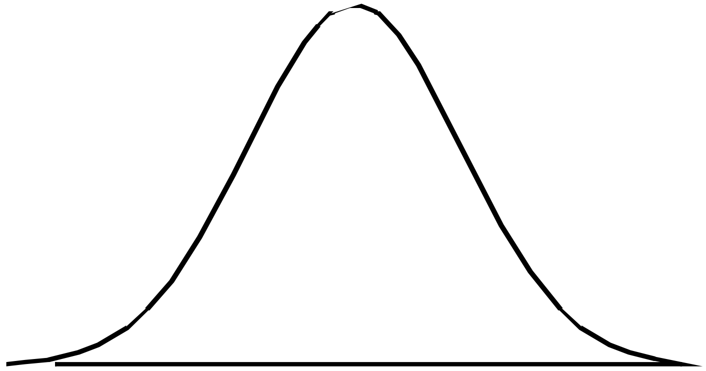
		A_1A_1	A_1A_2	A_2A_2
		-1	0	1
B_1B_1	-1	-2	-1	0
B_1B_2	0	-1	0	1
B_2B_2	1	0	1	2

Lots of loci/alleles →

Variation in populations

- part of it is genetic variation
- part of it is environmental variation

Genetic and environmental effect usually normally distributed



Comparison of single gene traits and quantitative traits

	Quantitative	Qualitative
Distributions	Unimodal and continuous	Multimodal and discrete
Genotype-Phenotype relationship	Incomplete	Close
Loci	Many	Few (one)
Environmental effects	Often Large	Usually Small
Parameters for describing	Means, variances, h^2, V^A	p and q
Examples	Reproductive Fitness, weight , height, milk production	Eye and coat colour Polled and horned Genetic defects

Reference: R Frankham, J.D. Ballou and D. A Briscoe. 2002. Introduction to Conservation Genetics. Cambridge University Press. Cambridge, UK.

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