

3.5 Random deviations from Hardy-Weinberg equilibrium

Problems can occur with the H-W equilibrium in small populations, as a gene frequency can change by chance.

In the smallest possible population (1 male and 1 female), only 4 genes can be carried on to the next generation. In a two allele system with $p=0.5$, this corresponds to the 5 possible gene frequencies in the next generation, as shown below, when both parents have been heterozygotes (Aa):

AA	-	AA	$q=0$
AA	-	Aa	$q=0.25$
AA	-	aa	$q=0.5$
Aa	-	Aa	$q=0.5$
Aa	-	aa	$q=0.75$
aa	-	aa	$q=1$

If the gene frequency is 0 or 1, the gene is either fixed or lost. If 4 genes are drawn from a base population with a gene frequency of $p=0.5$, the chance of loss or fixation (all four genes are a or A) is $0.5^4 = 0.0625$.

The variance of the gene frequency corresponds to a binominal variance. This can be used in evaluating whether a population is small with random changes in gene frequencies or large with stable gene

The binominal variance is equal to $(p \cdot q) / (2 \cdot N)$, $2 \cdot N$ being equal to the number of genes transmitted to the next generation.

Figure 3.6 shows the standard deviations of the gene frequency (p) when the base population has an average gene frequency of 0.5. The new generation consists of N individuals with $2N$ genes. The

standard deviation has significance for the gene frequency when going from one generation to the next. The random process is important, when only a limited number of animals can carry on the genes. In Figure 3.6 it is clear that in a large population the standard deviation of the gene frequency is small. Which means that the H-W law is true in the large population, with constant gene frequencies from generation to generation

In cases of extreme low or high gene frequencies the number of individuals has even more significance if a gene is lost or fixed. In the large population even genes with very low frequencies would remain.

Rule of thumbs: It can be derived from Figure 3.6, that large populations are counted in hundreds not in tens.

The size of the population is the problem when considering endangered species. If a specie comes under 100 breeding individuals its chance to survive is when man helps to increase the effective population size, see chapter 9.3.

In the small population, if it survives, fast changes will occur away from the base population. Darwin described the phenomenon as 'evolution by isolation'. He based his theory on observations from the many isolated islands in the Pacific ocean. Here both the animals and plants differed strongly from the one on the continents.

Figure 3.6

Standard deviations from a gene frequency depending on population size.

