Chapter 6.12: Inbreeding at population level: the rate of inbreeding

In a population the level of inbreeding can be considered as the average inbreeding coefficient across all animals in the population at a certain point in time. As we have seen before, all animals in a population are related, even if it is only very slightly. Consequently, if we compare the average inbreeding coefficient across generations, it will always increase. This increase is called the rate of inbreeding or F.

The speed of increase will depend on the relatedness between the animals in the population. The more related the animals in a population are, the more their offspring will be inbred, and the larger the rate of inbreeding. The size of the rate of inbreeding provides an indication of:

- the risk of inbreeding depression
- the decrease in genetic diversity (and thus room for adaptive capacity of the animals in response to a change in the environment).

The rate of inbreeding per generation can be calculated in retrospect from the average inbreeding in the current generation in comparison to that in the previous, relative to what remains to 100% inbred:

\[ F = \frac{(F_{t+1} - F_t)}{(1 - F_t)} \]

For example, if the average inbreeding level in generation 5 is 3.5%, and in generation 6 it is 3.9%, then the rate of inbreeding is \((0.039 - 0.035)/(1-0.035)\) = 0.0041 = 0.41%. If you want to do the calculations in % then you subtract \(F_t\) from 100 instead of 1.

If only a single generation is considered then it is a good approximation to just consider the difference between both generations. However, for evaluations across multiple generations it is more accurate to divide by how much is left to complete inbreeding. This is because the increase in inbreeding level across generations is not linear. The maximum inbreeding level is 1 (fully inbred) and further increase is not possible in vertebrate animal populations. An increase in inbreeding level indicates an increase in the probability that an animal becomes homozygous for a locus on the genome. You can imagine that the more inbred an animal becomes, the smaller the probability that the remaining loci become homozygous in the offspring due to mating with a related animal. These related animals are inbred themselves, and thus homozygous for a proportion of their loci. The offspring will also be homozygous for those loci, but that is not an increase in homozygosity, because both parents already were homozygous. Of course the offspring is still very inbred, the level of inbreeding is increasing every generation until all animals are fully inbred. But the speed at which this occurs, relative to full inbreeding, is decreasing when the average inbreeding levels become high. In figure 89 you see the relation between the average inbreeding level in a population across generations and population size, assuming random mating amongst the individuals. Obviously, the level of inbreeding is increasing the fastest in the smallest population. The dotted red line indicates that for these population sizes it is ok to assume a linear increase in inbreeding level for the first five generations since the population was founded! In reality the populations usually already exist for many generations, so the initial value of the inbreeding coefficient in the first generation you consider will not be 0. Keeping that in mind, it is always wise, in all populations, to express the rate of inbreeding relative to how much is still left to full inbreeding.
For example, if the average inbreeding level in a population is 0.23, and it was 0.21 in the previous generation, then the rate of inbreeding is \( \frac{0.23 - 0.21}{1 - 0.21} = 0.0253 \). This is more than \( 0.23 - 0.21 = 0.02 \), illustrating that not taking the non-linear increase in inbreeding level into account may result in an underestimation of the situation.