## Dealing with Inbreeding (1)

# What is inbreeding and what can be the consequences?

**Dealing with inbreeding is part of breeding. The Friesian breed has thanks to inbreeding become what it is today and it will continue to develop in whatever way breeders deal with inbreeding. In three parts we will explain the phenomenon inbreeding and the consequences for the breeding of the Friesian horse.**

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We speak of inbreeding when two animals that are bred to each other are related to each other. This means that the pedigrees of both animals minimally somewhere have one ancestor in common.

In the past especially practical obstacles that stood in the way of distribution of genetic material across large distances created inbreeding. Small local sub populations would come about within a breed with often within this sub population much mutual kinship. These days genetic material can travel to every corner of the world in the form of frozen semen, embryos, and breeding animals. But with that inbreeding and inbreeding issues are not a thing of the past. With these same modern techniques top animals can produce many offspring in a worldwide population. Inbreeding and the danger that genetic variation will forever become lost are a real danger. The connection between inbreeding and selection and the consequences it has for the KFPS breeding policies will be covered in the last part of this series 'Dealing with Inbreeding.'

The degree of kinship between two animals is indicated with a number between 0 and 1, which we call the kinship degree. The kinship degree between a sire and his daughter is 0.5, because half of the genes of the sire can be found in the daughter. The kinship degree between sire and granddaughter is 0.25 (-0.5 x 0.5), that between sire and great granddaughter 0.125 (= 0.5 x 0.5 x 0.5), etc.

If there is kinship between two animals and they are bred this results in an offspring that is inbred on the common ancestors. The degree of inbreeding is indicated with the inbreeding coefficient or the inbreeding percentage. The inbreeding coefficient is a number between 0 and 1 or a percentage between 0 and 100% and is equal to half of the kinship degree between the two parents. In order to prevent risky breedings with relation to hereditary defects the inbreeding percentage over the last five generations is calculated for the breeding of Friesians and a limit of 5% is used. In 'Dealing with Inbreeding,' part 2 we will further cover the pros and cons of this management. The inbreeding coefficient is a measure for the expected increase of how homozygousnes (breeding purity) in the offspring.

### Increase in breeding purity

What does 'the expected increase in breeding purity' mean? For the genes on the chromosomes of an individual

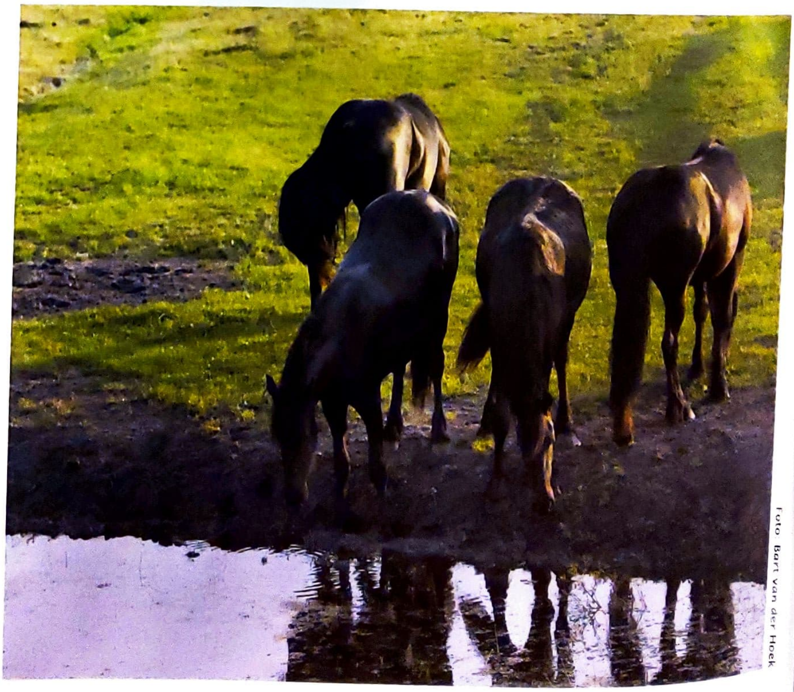


Foto Bart van der Hoek

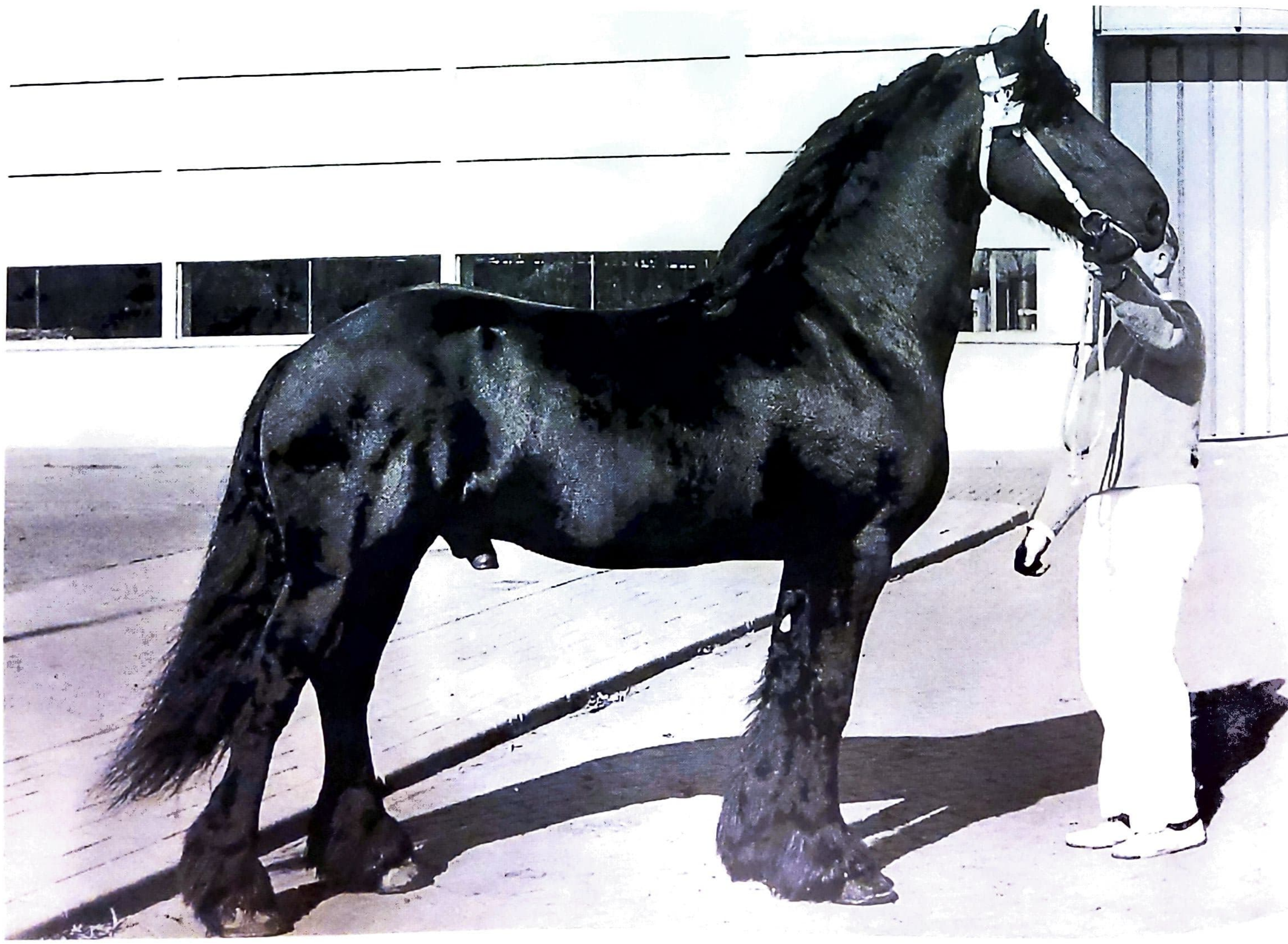
breeding companies as so-called production hybrids. These hybrids are the result of the combination of animals from a line with a high degree of inbreeding of one breed with animals with a high degree of inbreeding from another breed. By first inbreeding on the base breeds you create more and more breeding purity and genetic uniformity within the lines. Then the animals of the various inbred lines are paired. We call this outbreeding or crossing. This method of operation has a number of advantages:

1. The cross product (hybrid) combines the genetic characteristics of the original lines.
2. The crosses are genetically very much uniform. They have after all obtained the same genes from the father's side and from the mother's side very different genes, but still all the same.
3. By outbreeding in very many places on the chromosomes heterozygous gene pares come about. In practice we have found that for certain characteristics heterozygous geno types work out much more favorably than two exactly the same genes in a certain place.

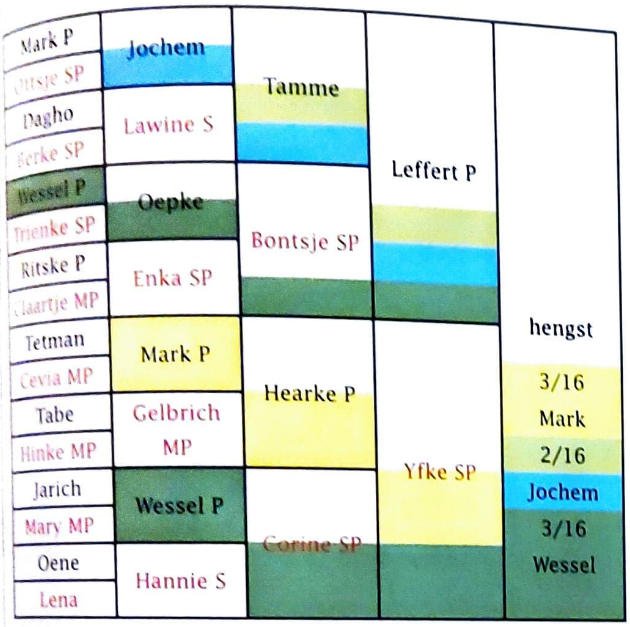
### Fitness characteristics

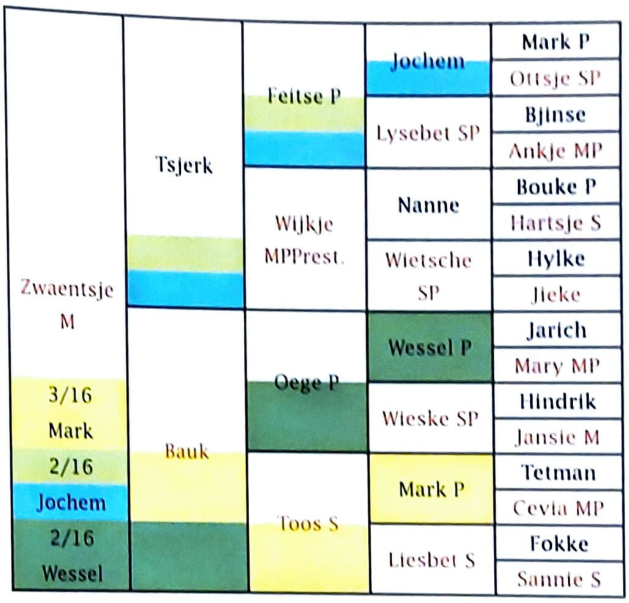
This applies especially to characteristics that are connected to the continuance of the species, e.g., resistance to disease, lifespan, fertility, and vitality. We call that the fitness characteristics. Less heterozygousnes leads to a decline in fitness characteristics and more heterozygousnes leads to a longer lifespan, better fertility, and more resistance. That is not just the case for poultry but also for Friesian horses. The fact that the average semen quality of Friesian stallions is considerably less than, e.g., that of KWPN stallions is more than likely a result of inbreeding and the connected decrease of heterozygousnes. The trick is now to select animals and combine them such that the desired characteristics are maximally expressed in the offspring without compromising the fitness characteristics any further. When a Friesian mare with excellent breed typical characteristics is paired with a stallion that also stands out in breed type then that is a method to anchor these breed typical characteristics with breeding purity in the offspring. If the stallion and mare in question both derive their excellent breed typical characteristics from a mutual ancestor that passes on breed type then the chance at success where it concerns anchoring with breeding purity will only increase. In a number of cases this can, however, go together with a decrease in fitness in the offspring. Successful breeding with Friesian horses means, therefore, to not always choose for as little inbreeding as possible but to responsibly deal with inbreeding. •

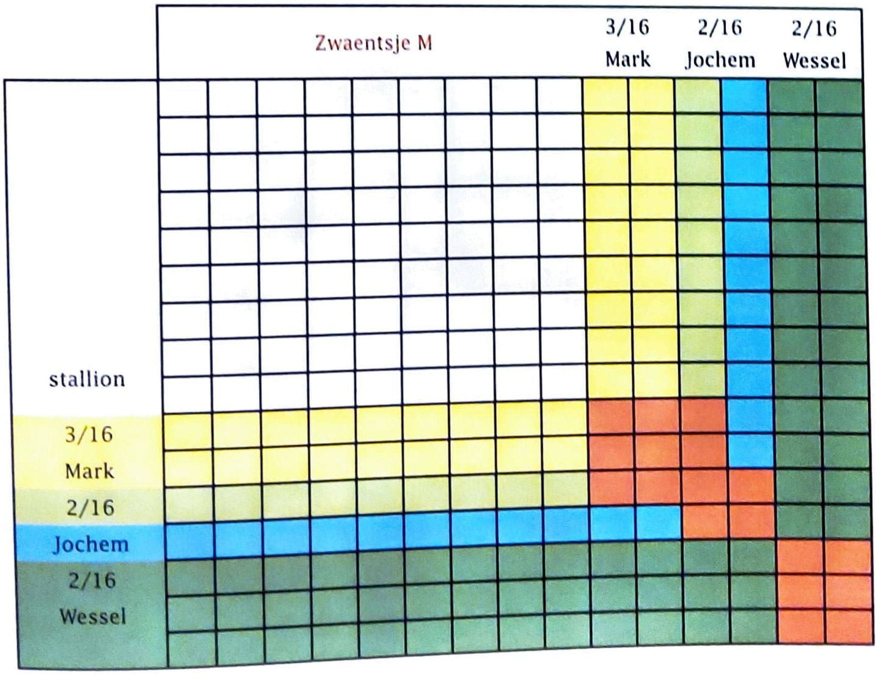
In this Phryso you will find Dealing With Inbreeding part 2: Stallion Choice and Inbreeding.



As an example we printed the pedigree of Lieke. The ancestors, which Lieke's father and mother have in common are the stallions Mark, Wessel, and Jochem. The structure of the gene package, also called blood lines, is indicated with colors. Yellow is Mark blood, blue is Jochem blood, and green is Wessel blood. The pedigree shows that Lieke's sire carries 3/16 = 18.75% Mark blood, 2/16 = 12.5% Jochem blood, and 3/16 = 18.75% Wessel blood. The overlap of yellow and blue indicates the mutual kinship of Jochem and Mark. Jochem was after all a son of Mark and even has 50% Mark blood. Zwaentsje, the dam of Lieke, in turn carries 3/16 = 18.75% Mark blood, 2/16 = 12.5% Jochem blood, and 2/16 = 12.5% Wessel blood. The red areas indicate the mutual kinship between the sire and dam of Lieke (calculated over the last five generations). The surface of the red areas indicates that 18/256 parts of the gene package of Lieke's sire is the same as that of Lieke's dam and v.v. The kinship between the sire and Zwaentsje is therefore 18/256 = 7.03%. The inbreeding percentage of Lieke is half of that and is thus equal to 3.52%. Still calculated over the last five generation. Looking at five generations is the minimum to obtain an indication of the mutual kinship and the inbreeding percentage that goes with it. More generations will produce a higher and more reliable number but requires much more calculating. Calculated over six generations Lieke has an inbreeding percentage of 4.54%, over seven generations 6.35%, eight generations 7.98%, and over all registered generations even 18.31%.



goes that they exist in pairs. Such a gene pair can exist of two of the same (homozygote), e.g., AA or two different ones (heterozygote) Aa. If no selection took place on A or a, a population consists of 25% genotype AA, 50% genotype Aa, and 25% genotype aa. Half of the population is thus heterozygous for gene A and the other half is homozygous. When ovums and sperm cells are formed all gene pairs are split. With heterozygous individuals half of the sex cells (sperm cells or ovums) contain the one gene A and the other half the other gene a. That gives the offspring a certain uncertainty when it concerns the materialization of the characteristic that is determined by gene A. The heterozygous individual we call breeding unpure for gene A and characteristic A. In the case of the father/daughter combination you can calculate that the frequency division of AA, Aa, and aa in the offspring is not ¼, ½, ¼ but 5/16, 6/16, 5/16. The increase in degree of homozygousnes or decrease of heterozygousnes is even to 2/16 divided by ½ = 0.25. The offspring of a father/daughter combination, therefore, have an inbreeding coefficient of 0.25 and that can also be calculated as half of 0.5, being the degree of kinship between father and daughter. This system does not just count for gene A with a father/daughter combination but goes for all genes when combining related horses. Inbreeding, therefore, leads to a shift to fewer heterozygous and more homozygous geno types in the offspring. More homozygous gene pairs means that for more and more genetic characteristics goes that it no longer matters which of the two genes end up in a certain offspring, because they are after all exactly alike. We call that breedin purity. For a portion of the genetic characteristics that is definitely favorable. No one, e.g., will have difficulty with it if the breeding purity of the characteristic 'no white markings' increases and thus fewer and fewer offspring are born with markings out of parents without markings. The same goes for a large number of other genetic characteristics.

**Line breeding**

Specific use of inbreeding is a method to increase breeding purity. For certain purposes of use repeated inbreeding is applied to breed offspring that become more and more uniform and, if you continue this long enough, eventually genetically identical. For animal tests it is very handy if the results are not influenced by genetic differences between the test animals used. For that reason rat and mice lines have been bred that have been inbred into each other for so many subsequent generations that all animals within such a line are genetically identical. Another example comes from small animal sport breeding. There it is an often used method, by means of repeated father/daughter or son/mother breedings, to anchor characteristics of an animal that highly adheres to the breeding goal in a line. In this fashion the offspring of a repeated father/daughter combination will more and more resemble the line father. Production animals in poultry farming are brought to market by specialized

**Overview of concepts and technical terms**

**Chromosomes:** part of the cell nucleus that stores all hereditary information.

**Fitness characteristics**: all characteristics that are related to the continuance of the species, e.g., resistance to disease, lifespan, fertility, and vitality.

**Breeding unpure:** an animal is breeding unpure for a certain characteristic if one or more gene pairs that determine the expression of the characteristic are heterozygous. This leads to itemization at the formation of sex cells with therefore a bigger chance of different offspring.

**Breeding pure:** an animal is breeding pure for a certain characteristic if all gene pairs that determine the characteristic are homozygous. It then no longer matters for the characteristic in question which sex cell will create a new individual.

Gene pair: the chromosomes can be found in pairs in the cell nuclei of an individual. Of every pair one comes from the father and the other from the mother. The various parts of these carriers of the genetic material we call genes and those thus also come in pairs.

**Heterozygote:** a gene pair that received two different genes from father and mother.

**Heterozygousnes**: the presence of heterozygous gene pairs.

**Homozygote:** A gene pair that received two of the same genes from father and mother.

**Homozygousnes:** the presence of homozygous gene pairs.

**Hybrids:** offspring that are the product of outbreeding.

**Inbreeding:** pairing of individuals that are related.

**Inbreeding coefficient:** a number between 0 and 1 that indicates the relative increase of homozygousnes of a certain combination.

**Inbreeding percentage:** a number between 0 and 100% that indicates the relative increase of homzygousnes of a certain combination.

**Line breeding:** repeated inbreeding with the goal to anchor characteristics in the offspring with breeding purity and/or more genetic uniformity in the offspring.

**Outbreeding:** combining of individuals that are not or clearly less related.

**Kinship:** the presence of one or more common ancestors in the pedigree of two or more individuals.

**Degree of kinship:** a number between 01 and 1 that indicates the degree of similarity in the pedigree.

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