REDEFINITION OF THE COEFFICIENT OF RELATIONSHIP BY TAKING THE SEX CHROMOSOMES INTO ACCOUNT

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The coefficient of relationship has been defined by S. Wright (1922). It gives the probability of identical genes in a locus in two individuals and thereby the expected correlation between them. The identity is not by allelic form but by inheritance of an identical 'by descent' allele from a common ancestor. The coefficient of relationship between father and son or father and daughter was by definition a half, since the son or daughter receives half of the chromosome material from the father. The other half is inherited from the mother. When the definition was given the chromosomes as carrier of the information was not known in any details but the definition has appeared reasonable right since it was used the first time. For most practical purposes this old definition is more than sufficiently precise.

But the old definition of the coefficient of relationship does not take into account that the transmission of the sex chromosomes have special rules, where a male receive its Y-chromosome from the father and its X-chromosome from the mother.

Today it is known that the X-chromosome contains around five per cent of the mammalian genome and the Y-chromosome contains around 1 percent with only a few genes (Lewalski et al., 1993). So if the rule of probability of identical genes in father and son is applied strictly, the coefficient of relationship between father and son is less than a half, as the five per cent in the X-chromosome do not contribute to the identity, and the son always receives the X-chromosome from the mother. So for mammals the coefficient of relationship between father and son should be 0.4792 rather than 0.50. The coefficient of relationship between father and daughter should be higher than 0.50 as they share a common X-chromosome, indeed it should be 0.5104. For the mother and daughter relationship the coefficient of relationship should be as defined 0.50, whereas the mother son relationship is higher than 0.50, indeed it should be 0.5104.

As modern breeding value estimations are based on very sophisticated statistical methods with inclusion of millions of relationship coefficients according to the methods of Henderson, (1975) ; redefinition of the old definitions seems warranted. A more correct relationship coefficient can improve the breeding value estimation and thereby the selection procedures for domestic animals. The coefficients of relationship are also an important part of parameter estimation, both for heritability estimation and for estimation of common environmental effect for individuals in for instance a pig litter. Full- and half sib correlations are also changed when sex chromosomes are taken into account. A complete additive relationship matrix can be derived for a population taking the sex chromosome material into account. When transferring genetic material from father to offspring the coefficient depends on the sex of the offspring.
The new definitions are based on the following assumptions and calculations
1. The X-chromosome constitutes 5 per cent of the genome.
2. The Y-chromosome constitutes 1 per cent of the genome.
3. X-chromosome inactivation in the female has no implications.
4. Expected correlations is estimated as common amounts of genetic material divided by the square root of the product of the total material in for instance father and son.
5. The total genetic material in a female is set to 100 units.
6. The total genetic material in a male is set to 96 units.
7. Shared material in a father and son is set 46 units.
8. Shared material in father and daughter is set to 50 units.
9. Shared material in mother and son is set to 50 units.
10. Expected correlation father son = 46/SQRT(96*96) = 0.4792.
11. Expected correlation father daughter = 50/SQRT(96*100) = 0.5104.
12. Expected correlation mother son = 50/SQRT(100*96) = 0.5104.

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