Introduction to Animal Reproduction

Genetics is the science of inheritance, the study of the passage of traits from one generation to its offspring. A knowledge of genetics can help the producer determine the characteristics that will likely be passed on through breeding.

Genes and Their Function

A gene is the unit of inheritance. Inheritable traits are carried to offspring during reproduction by the genes of its parents. The genes found in a particular cell determine what that cell will be like, and thus what the body made up of those cells will look like. The component of the gene that controls inheritance is deoxyribonucleic acid (DNA).

Chromosomes and Their Function

Chromosomes are long, slender, threadlike structures found in the nucleus of a cell. The chromosome carries the genes responsible for the inherited traits of the animal. Each chromosome carries hundreds of genes, which are found at a fixed location. Chromosomes occur in pairs, and thus so do genes. The genes appear side by side on the paired chromosomes. Figure 6.1 illustrates the pairing of genes and chromosomes.

Figure 6.1 - Chromosomes and Genes

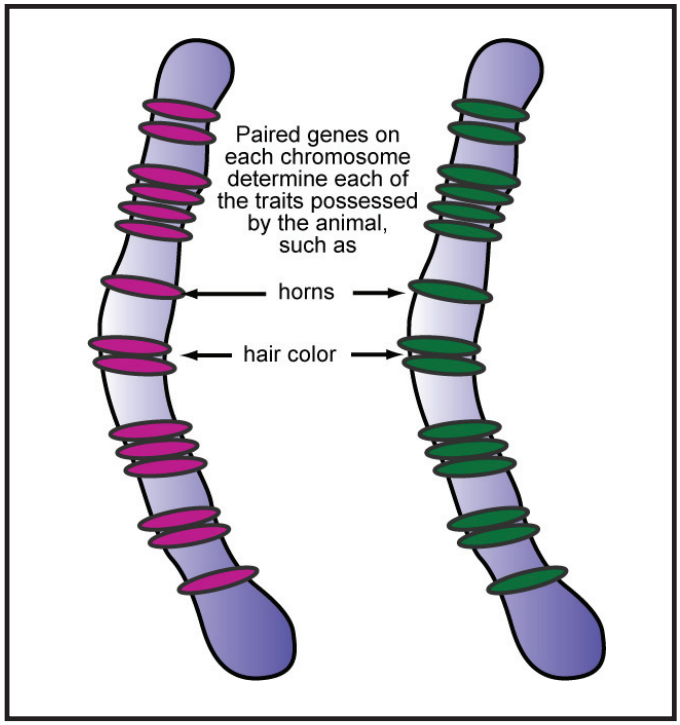


Table 6.1 - Chromosome Numbers

Species	Chromosomes	Pairs
Cattle	60	30
Swine	38	19
Fowl (poultry)	78	39
Sheep	54	27
Horses	64	32
Dogs	78	39
Rabbits	44	22

The reproductive cells (sperm and ova) are different from other cells in that they possess single rather than paired chromosomes. In human beings, for example, reproductive cells have 23 chromosomes, while other cells have 23 pairs of chromosomes. When the sperm and egg unite at conception, the fertilized egg has 23 pairs of chromosomes combining genetic material from the mother and father.

Different animal species have different numbers of chromosomes. Look at Table 6.1 to compare species. Cattle have 60 chromosomes, while swine have 38 chromosomes. The numbers of chromosomes found in fowl vary, but poultry have 78 chromosomes. Sheep have 54 chromosomes. A horse has 64 chromosomes, and a dog has 78. Rabbits have 44 chromosomes. To find the number of pairs, divide the number of chromosomes by two.

Dominant and Recessive Genes

Most of the traits that are expressed in offspring are determined by the combination of several gene pairs. However, some characteristics are determined by only a single pair. In that case, the interaction of the genes making up the pair can be traced, and the likelihood of whether or not an unborn animal will possess the associated trait can be calculated.

Not all of the genes inherited from its parents have a visible effect on the offspring. Some genes, called dominant genes, hide a paired gene's characteristic. The gene of the suppressed or hidden trait is called a recessive gene. The way in which the dominant and recessive genes match up at conception determines the trait that will be found in the offspring. Even if the gene pair has only one dominant

gene, the newborn will exhibit that trait. The recessive trait will only be exhibited if the gene pair is composed of two recessive genes.

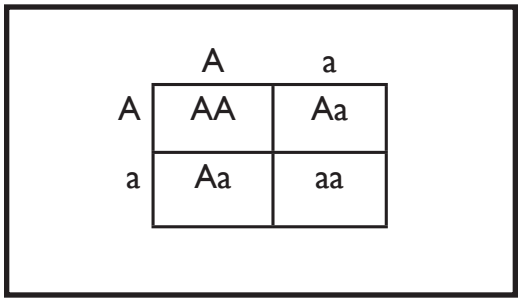
Sometimes neither of the genes in a gene pair is dominant. Incomplete dominance is the result of the joint action of the genes, both of which have an effect on the characteristic controlled by that gene pair. For example, in shorthorn cattle, the coat color may be red, white, or roan, which results from the interaction of the genes for red and white coat color.

The possible combinations of dominant and recessive gene pairs found in offspring can be predicted with a checkerboard system, which makes use of a set of boxes that form what is referred to as a Punnet square. As an example, suppose that a polled cow is to be mated to a polled bull. Horns are a recessive trait, while the polled characteristic is dominant. It is known that both cow and bull possess the recessive gene as well as the dominant one.

When recording the genetic makeup of each animal, a capital letter is used to indicate the dominant gene and a lowercase letter is used to indicate the recessive gene. In the example, a large A is used to represent the dominant polled gene and a small a indicates the recessive horned gene. The cow and bull thus each have a gene pair of Aa.

The bull's gene pair is placed on top of the Punnet square and the cow's placed on the side, one gene for each box on that side of the square. For the bull, the large A is placed over the first column and the small a over the second column, while the cow's large A is written next to the first row with the small a next to the second. Each of the boxes in the square represents a possible gene pair for the offspring. For each column and row the gene's letter is brought down or across. For example, the male has an A in the first column that is carried down the two boxes in the column. The result is four possible gene pairs of AA, Aa, Aa, and aa, as shown in Figure 6.2.

Figure 6.2 - Aa x Aa Cross



According to the Punnet square, two of the offspring are heterozygous, and two are homozygous. A heterozygous animal is one that carries two different genes for a particular characteristic (Aa). A homozygous animal is one that carries identical genes for a characteristic (AA, aa).

The outward physical appearance of the animal is called the phenotype. Of the four possibilities for offspring, three will be polled, because they possess the dominant A gene. Only one of the possibilities will be horned. So the phenotypic ratio is 3:1, with three polled and one horned.

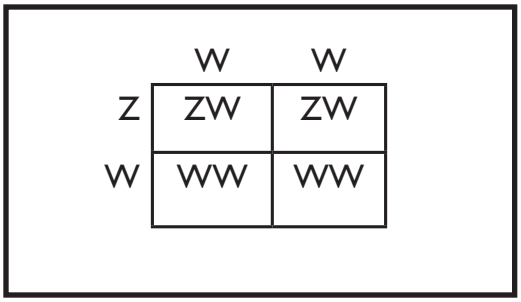
The gene pair possibilities can also be analyzed according to the actual genes found in each pair. The genetic makeup of an individual is referred to as the genotype. In the example, there are three different genotypes, with one AA, two Aa, and one aa. The genotypic ratio is 1:2:1.

Sex Determination in Offspring

Genetic inheritance also determines the sex of offspring. In most species, the X and Y chromosomes determine sex, with X being the female chromosome and Y the male chromosome. A female has a chromosome pair of XX and so can only give offspring an X chromosome. The male's chromosome pair is XY. The male therefore determines the sex of offspring, since he can contribute an X or a Y chromosome. The sex of the offspring depends on whether the X or the Y chromosome is present in the sperm that joins with the egg at conception.

In contrast, the female determines the sex in fowl. The process is the same, but the female and male roles are switched, since the female has two different

Figure 6.3 - Sex Determination in Fowl



chromosomes while both of the male's are the same. Figure 6.3 illustrates sex determination in fowl, with WW standing for the male chromosome pair and ZW for the female pair.

Summary

A gene is a unit of inheritance that is located on a chromosome. Each animal species has a specific number of chromosomes, which are found in pairs. The gene pairs on these paired chromosomes determine the characteristics of the animal, which can be passed on to its offspring through the reproductive cells. A Punnet square can be used to predict the relationship of dominant and recessive genes in offspring when the male and female are mated. Genetic inheritance determines not only the traits but also the sex of the offspring.

Credits

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Warren, D. M. *Small Animal Care and Management*. Albany, N.Y.: Delmar Publishers, 1995.