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Oklahoma Cooperative Extension Service • Division of Agricultural Sciences and Natural Resources

How Inheritance Works In Swine

In order to produce the best animals possible in a live-stock operation, we must give them the best environment feasible (nutrition, housing, management) and improve the genetic quality of the animal. However, to do this, we must understand how inheritance works.

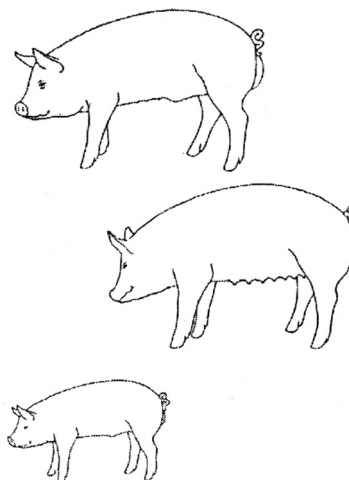
Resemblance Between Relatives

As early as the 1700's, successful livestock breeders observed that the more desirable animals in their herds generally produced offspring that were better, and less desirable animals produced offspring that were not as desirable. This superiority or inferiority was passed from parent to offspring. However, what was actually passed was not discovered for a number of years.

First, it was found that the bodies of all animals were made of millions of microscopic cells. These cells have two major parts: cytoplasm and nucleus (nucleus being the center of the cell). Eventually scientists figured out what was physically passed from parent to offspring were parts of the nucleus called "chromosomes." These chromosomes were then discovered to have many nucleotides (combination of a phosphate, sugar, and nitrogenous base) attached end-to-end in a twisting, double-spiral shape. These nucleotides differ only in the type of nitrogenous base they contain. Since five different bases were found, there exist only five different nucleotides.

It was later discovered that the expression of a trait (such as black or red coat color) was determined by the order of nucleotides in a segment of the chromosome. This is the gene, the basic unit of inheritance. A chromosome, then, consists of many genes arranged end-to-end.

Chromosomes occur in pairs in the nucleus, and each species of farm animals has its own number of chromosome pairs: cattle (30), horses (33), pigs (19), and sheep (27). In the process of reproduction (meiosis) each parent produces a gamete = egg). When the sperm fertilizes the egg, the male chromosomes pair up with the chromosomes from the female to give the offspring a complete set of paired chromosomes (one-half from sire, one-half from dam). Thus, the genetic composition of the offspring is a result of the chromosomes passed on from the sire and dam. As a result, offspring resemble their parents.



Genetic Control of Expression of Traits

Since chromosomes occur in pairs and each chromosome of the pair has a gene that influences a particular trait, then genes also occur in pairs. The actual genes an animal possesses for a trait is called the genotype. For example: Two genes controlling coat color in cattle are (a) R= red color; (b) W= white color. These are two different genes (different order of nucleotides) that can occupy the position on the chromosome that controls coat color. They are referred to as alleles. Since an animal has two genes controlling a trait, they could be RR, WW, or RW. If both genes present code for the same color (RR or WW), it is called a homozygous genotype. If the two genes code for different colors, it is called a heterozygous genotype.

However, when we observe the animal we cannot see its genotype; we see the coat color. This is called the phenotype. If the animal is RR (homozygous red) genotype, its phenotype will be red, since only red genes are present. A WW genotype results in a white color, since only white genes are present. But what if the genotype is heterozygous (RW)? The phenotype will depend on how the two genes interact. This is called "gene action." In our example, the R and W alleles are codominant (both are expressed at the same time). This

results in a phenotype consisting of both red and white hair called a roan coat color. The association between genotype and phenotype is shown in the genetic key:

Genotype	Phenotype
RR	Red
RW	Roan
WW	White

Another form of gene action is seen in how the W (white) gene interacts with its B (black) allele in swine. The B gene codes for the animal having black color. The homozygous white (WW) animal is white; the homozygous BB animal is black. However, the heterozygote (WB) is white (identical in appearance to the WW). The gene action here (called “complete dominance”) is where the W allele completely dominates or covers up the phenotypic expression of the B allele. The genetic key is:

Genotype	Phenotype
WW	White
WB	White
BB	Black

One point to realize here is that the WW animal is indistinguishable from the WB animal in appearance, yet he carries the black allele. The heterozygote then, with complete dominance, is called a “carrier.”

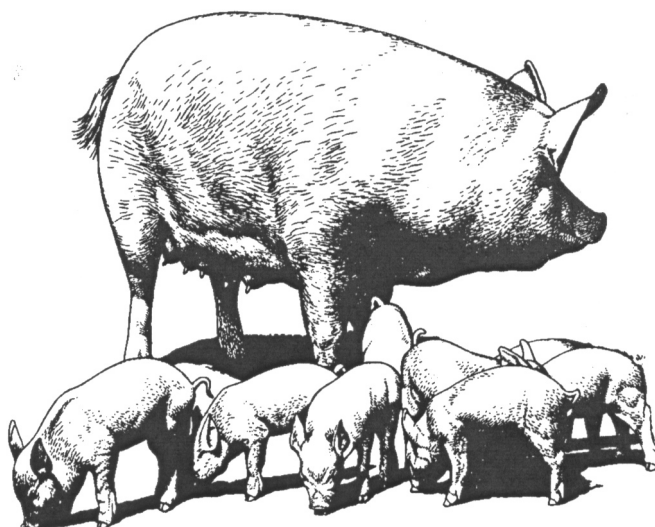
The most common and most economically important type of gene action is additive gene action. Traits in swine such as litter size, growth rate, and backfat are controlled by this type of gene action. However, unlike the gene actions previously described, additive is not a simple gene action. Rather than two alleles at work, there are hundreds of alleles (each with a different effect) at hundreds of positions on the chromosome. The interaction between each allele is additive. Let’s go through a simple example, then expand it to actuality. Suppose in humans there was one gene that controlled skin color and three alleles (different forms of that gene). Allele A= 0% color, B = 25% color, C = 50% color (coded for through melanin production). These alleles would not dominate each other (additive action). The genetic key for all purpose genotypes would be:

Genotype	Phenotype
AA	(0 color + 0 color) = no color = albino
AB	(0 color + 25% color) = 25% color = light
BB	(25% color + 25% color) = 50% color = mulatto
AC	(0 color + 50% color) = 50% color = mulatto
BC	(25% color + 50%) = 75% color = dark
CC	(50% color + 50%) = 100% color = black

There is now a continuous range of phenotypes with more possible skin colors. Since there are really many genes with many alleles, the skin color in the world varies from albino to black.

Inheritance of Sex

In farm animals, the sex is determined by the one pair of chromosomes that are not identical to each other (sex chromosomes). One of the pair is normal (X), while the other of the pair is shortened and crooked (Y). If an animal has sex



chromosomes XY, it is a male. If an animal has sex chromosomes XX, it is a female. Since each parent gives one of each pair of chromosomes to its gamete, the female must give an X or Y sex chromosome. Therefore, which sex chromosome the male gamete contains determines the sex of the animal (it is a chance event).

Variation

Our animal populations are interbreeding groups of non-identical animals. Some animals are white, some black. Some weight 230 pounds, some 500 pounds. These measurable or detectable differences between individual phenotypes in referred to as phenotypic variation. Suppose you had a herd of hogs and the average litter size was 8.0 pigs weaned. If sow 19-2 weaned 12.0 pigs in her litter, she would be phenotypically 4.0 pigs above average. This phenotypic difference from the mean is called her selection differential. Why is she better than average?

- she had a better environment (warmer, drier, etc.)
- she was genetically superior

The portion of that phenotypic advantage due to superior genetics is the heritability of the trait (litter size).

Each trait has its own characteristic heritability. Reproductive traits (conception rate, litter size) are primarily influenced by environment; thus, their heritability is low (5 to 15%). Production traits (growth rate, feed efficiency, milk production) are moderately heritable (20 to 35%). Carcass traits (backfat, loin eye area, percent muscle) are highly heritable (40 to 60%). Traits such as color are very highly heritable (70 to 90%). Heritability is a measure of the genetic control of a trait.

Genetic Merit

The genetic merit of an animal is the genetic content compared to the rest of the animals. This is referred to as the breeding value and is the genetic portion of the selection differential. Therefore, our sow, 19-2 (if heritability for litter size=15%) has a breeding value = selection differential X heritability = +4.0 X 15%= + .6 pigs/litter weaned.

Questions

1. The basic unit of inheritance is? _____
2. The gametes produced by the male are? _____
And by the female? _____
3. Species differ in the number of pairs by? _____
4. The actual genetic content of an animal for a trait is referred to as its? _____
5. The gene action when one allele completely covers up the phenotype expression of another allele is?

6. Detectable differences between individuals is referred to as? _____
7. The phenotype difference due to genetics is?

8. The phenotypic difference of an animal from the average is? _____
9. An estimate of the genetic merit of an animal is referred to as? _____

Activities

1. Visit a commercial swine farm and record the color and ear carriage (erect or drooped) of boars, the sows they are mated to, and the color and ear carriage of their offspring.
2. Obtain laboratory animals with known genotypes for certain traits and make crosses between them to observe the phenotypic results in order to figure out the mode of inheritance.
3. Record the blood types of your family in order to explain their inheritance.

Other Resources

1. Pork industry Handbook
 - a) Selection Guidelines PIH-58
 - b) Boar Selection PIH-9
 - c) Crossbreeding Programs PIH-39
2. Bulletins, circulars, and factsheets in county Extension offices.

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The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

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- More than a million volunteers help multiply the impact of the Extension professional staff.
- It dispenses no funds to the public.
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- Local programs are developed and carried out in full recognition of national problems and goals.
- The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
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