Genetics De-Mystified

Currently, in the world of herpetoculture, there are an ever increasing number of color and/or pattern abnormalities (often referred to as "morphs") being produced in snakes. For example, there are presently over 100 such abnormalities in the Corn snake (*Pantherophis g. guttata*). But how is this done? The answer lays in Mendelian genetics. The topic of genetics can be complicated (and confusing) for many, so I will explain the basics and will define the terms as they come up.

To start, an animal's genes contain different forms known as alleles. This is known as being heterozygous (which is often abbreviated "het"). These alleles can either be recessive or dominant. Recessive alleles can only appear in the offspring (otherwise known as its phenotype) if it is in the homozygous. Essentially, homozygous means having identical alleles at a specific location on the chromosome. Dominant alleles, however, affect the phenotype if homozygous or heterozygous. For example, an animal that is heterozygous for albino will appear normal (since the wild type allele is considered dominant), but still possess the recessive allele for albinism.

A Punnett square (which, when blank, is a simple four box grid) can then be used to predict the possible results of a given cross. Using the simplest monohybrid example possible, the gametes for one parent (beginning with the dominant trait) are written above the square, while the gametes for the other parent are written down the left side of the square. The name of the abnormality is always abbreviated (such as "a" for albino, which is recessive and is thus lowercase). When filling out the boxes, the dominant trait (which is always uppercase) should be written before the recessive trait. A plus symbol as a superscript may also be added to those abbreviations for wild type alleles.

It should be noted however that the Punnett square is intended to be a tool for predicting possible outcomes and assumes perfect/ideal results. Oftentimes, the actual results of a given clutch differ (by either more or less) than what has been predicted by a Punnett Square.

Glossary of Terms

Allele: One of a pair of alternative forms of a gene that both occupy the same chromosome.

Amelanistic (Amel): When an animal is lacking melanin, or black pigment.

Anerythristic (Anery): When an animal is lacking, or exhibiting reduced red pigmentation.

Axanthic: When an animal is lacking or exhibiting reduced yellow pigmentation.

Co-Dominant (Co-dom): The characteristic of when both traits or mutations on both alleles are expressed in the animal's phenotype.

Dominant: The characteristic of a particular trait or mutation on a particular allele that is expressed over other traits/mutations on other alleles.

Double Heterozygous (or Double hets): Animals that possess two seperate traits or mutations on seperate alleles of seperate chromosomes.

Genotype: The overall genetic composition and makeup of an animal.

Heterozygous (Het.): Having two different traits or mutations (one on each allele) of a chromosome. In simple recessive genetics, the recessive allele for a particular trait is masked by the dominant allele causing the animal's phenotype to appear normal. Therefore the animal is said to be heterozygous, or het.

Homozygous: Having the same trait or mutation expressed on both alleles of a chromosome, and which is therefore expressed as the animal's phenotype.

Hybrid: An offspring produced from at least two genetically different species or taxa.

Hyper- melanistic, or Melanistic: When an animal posseses an atypically high amount of melanin or dark pigment, giving the animal a black, or darker than usual phenotype.

Hypomelanistic (Hypo): When an animal possesses reduced amount of dark pigmentation.

Intergrade: An offspring produced from at least two distinct subspecies, but are still regarded as the same species. Intergrades often occur naturally where the ranges of subspecies meet or overlap.

Leucism (Leucistic): Occurs when all of an animal's skin pigmentation is absent or significantly reduced, with the execption of the irises. Not to be confused with Albinsim.

Melanistic: See Hyper melanistic.

Morph: Any of the atypical colored and/or patterned animals produced and available in herpetoculture. Morphs can be simple or double recessive, dominant, co-dominant depending on the trait and the species .

Normal: See Wild Type.

Paradox: A genetic anomolly that is not yet fully understood, where an offspring displays an incomplete pheonotype to varying degrees. Paradoxes can occur by chance in any morph of animal and can manifest as small random spots or patches on a snake, all of the way to a completely mixed or blended phenotype of the animal.

Phenotype: The outward and visible characteristics of an animal, including its color and pattern.

Pie bald (or Pied): Occurs when an animal possesses variable sized patches on the body where pigmentation is absent. The best example is the pie bald ball python.

Polymorphic: Occurs when a species or taxa of animals possesses multiple phenotypes between specimens.

Possible Heterozygous (Possible Het.): An offspring from a known and paired breeding pair of parents that has either a 50% or 66% chance in theory of being heterozygous for a particular trait or mutation.

50% Possible Het.- Offspring with a normal phenotype produced from a homozygous and heterozygous parents, and where theoretically, 50% of the offspring will be heterozygous.

66% Possible Het.- Offspring with the wild phenotype produced from two heterozygous parents, and where theoretically, approxamately 2/3 (or 66%) of the normal looking offspring will be heterozygous.

Punnett Square: A simple four quadrant diagram used to predict offspring genetic outcomes of a known pairing or breeding of parent animals. The gametes of one parent are written accross the top, and the gametes of the other parent are written on the left side. Dominant traits or gametes are always a capitalized letter, and are written before recessive traits (which are always lower cased letters).

Simple Recessive: A genetic trait or mutation that changes an animal's phenotype only when present on both alleles of a chromosome.

Super: The dominant form of a co dominant trait or mutation.

Tyrosinase: (T-Positive and T-Negative): Tyrosinase is an enzyme required for producing melanin.

T Negative- is a strain of Albinism which lacks Tyrosinase, threfore producing a yellow and orange albino animal.

T Positive- is a strain of Albinism which possesses Tyrosinase, but is unable to produce melanin, therefore producing an albino animal with shades of lavender, gray, and/or brown.

Wild Type or Normal: The standard, naturally occuring phenotype (or color and pattern phase) of an animal.

Normal/Wild Type (NN) X Heterozygous Recessive (Na)

In the very simplest scenario, a normal, wild type (NN) is crossed with a heterogynous recessive parent (Na). In theory:

- 50% of the offspring will be wild types (NN)
-50% of the offspring will be Heterozygous Recessive (Na)

Heterozygous Recessive (Na) X Heterozygous Recessive (Na)

Here, a parent that is heterozygous for albino (Na) is crossed with a parent that is also heterozygous for albino (Na). The resulting offspring in theory would be:

- 25% albinos (aa)
- 50% Heterozygous Recessives for albinos (Na)
- 25% Normal, Wild types (NN)

However, it is not possible to distinguish he phenotypes of the normal wild types from het. for albinos that may be in this clutch. So, all hatchlings that have normal phenotypes are presumed to be possible hets., in this case, for albinos. Since 2/3 of the offspring that appear normal can be predicted to be hets. This is what is meant by 66% het albino.

Homozygous Recessive (aa) X Normal/Wild Type (NN)
In this example of simple recessive genetics, a homozygous for albino parent (aa) is crossed with a homozygous normal, wild type parent (NN).

- All of the offspring are heterozygous Recessive for albino (Na), since it is a recessive trait.

Homozygous Recessive (aa) X Heterozygous Recessive (Na)
Here, a homozygous for albino parent (aa) is crossed with a heterozygous for albino parent (Na). Ideally, the resulting offspring would be:

- 50% Homozygous albinos (aa)
- 50% Heterozygous Recessive for albinos (Na).

This is what is meant by 50% het. albino.

Co Dominant (NT*) X Normal/Wild Type (NN)
Some genetic traits are co-dominant in some species (such as ball pythons and common boas). Co-dominants are genes that both act dominantly unlike simple recessives, causing the animal to exhibit an intermediate phenotype between the two traits. A simple example would be the Tiger reticulated python Here, a normal, wild type retic (NN) is crossed with a co-dominant Tiger parent (NT*). In theory:

-50% of the offspring will be the normal type (NN)
-50% would be co dominant Tigers (NT*NT*)

Co Dominant (NT*) X Co Dominant (NT*)
If both parents are co-dominant (NT* and NT*):

- 25% of the offspring are wild types (NN)
- 50% are the co-dominant Tiger trait (NT*),
- 25% considered the super form of the co dominant (in this case Super Tiger Retic) , T*T*.

Super Co Dominant (T*T*) X Co Dominant (NT*)
If a Super Tiger, the Super form (T*T*) is bred with a co dominant Tiger form (NT*), in theory:

-50% of the offspring can be expected to be the co dominant form (Tiger)

-50% can be expected to be super tiger (T*T*).

Double Heterozygous Recessives (Double Hets)

When constructing Punnett squares for animals which are double heterozygous (or Double hets), matters become slightly more complicated. Double heterozygous recessive animals possess two different recessive traits on two different genes. For the purpose of this exercise, we will use a very simple, generic representation of these two heterozygous genes, Aa and Bb. Therefore, the genotype would be AaBb. This would be a double het.

Aa + Bb = AaBb

AaBb X AaBb

In this genotype, we have two different genes with four different alleles as a result. These are the two genes from both parent. There are four different combinations of these alleles that we could have:

AB, Ab, aB, and ab.

In constructing a Punnett square when both parents are double hets, we must devise a sixteen box grid instead of the simple four box grid we have seen with simple recessives and co dominants. Using our combinations from above, our Punnett square would look like this with one parent's genotype across the top, and the other parent's genotype on the left side like before. In predicting offspring genotype for each square, we simply combine the alleles, which have in this case, been color coded for simplification.

Conclusion

While there are obviously many more genetic crosses and combinations that can be, or are being done in the world of herpetoculture (including triple, and even quadruple hets), it is our hope that this page has at least covered all of the basics (including common terminology) when it comes to recessive, dominant, and co dominant traits, and that it has increased the awareness and understanding of successful breeding by new and aspiring herpetoculturists (as well as those of all levels) of how many of these morphs are produced.

With that said, it should be kept in mind that for most of these crosses, the actual genotype/phenotypes of the offspring are seldom, if ever, 100% predictable, and that, there often, lays much of the joy and anticipation held by many in the field of herpetoculture as to what will actually peek its nose past that eggshell.