Betta Genetics

Here is my attempt at giving some answers to betta genetics. The following information is obtained by observations of my own stock and from research done on other web sites and by reading publications in the IBC's *Flare!* You will find at the very bottom of this page, a list of some of the known symbols used for betta genetics, what they stand for, whether they are dominant, recessive or co-dominant.

One thing that is always important with genetics is the words that are used, otherwise known as terminology. I will try to make this as easy to understand and follow genetics "lesson" as I can. Let's start with the basics.

Genotype - This it the genetic makeup, or constitution, of an individual. This is the part you can't see but can be produced. Ever wonder why your sister had blonde hair while all the other members of your family had brown hair? Well, there you go. Your parents don't look it, but they got it.

Phenotype - This is what you can see, the physical description you give the cops of the guy who ran off with your shopping bag, purse, girlfriend ...

Allele - One of a pair of genes located at the same position on both chromosomes. In other words, each chromosome has a gene that codes for brown hair. That gene in is referred to as an allele. The matching chromosome has the same exact allele in the same exact place, thus a pair.

Homozygous - This is a term used to indicate that a plant or animal has two identical alleles at a single place on a chromosome. This results in an animal that breeds true for only one trait. An example would be that if your parents have brown hair, you have brown hair, all your grandparents and all their parents and grandparents have brown hair, chances are, you are homozygotic for only brown hair (that is all you can get, no blonde kids for you).

Heterozygous - The term used to indicate something that is not homozygous. The reason why you got a blonde sister. Your parents were heterozygotic for blonde hair.

Have I covered the basics? Okay, here goes the coding part. In genetics, instead of writing down "brown hair crossed with brown hair gives brown hair", scientists devised a short cut of writing this down. If anyone knows a scientist, you know how they love to abbreviate things so that only they can really understand what is going on. So, in this case we'll substitute (replace) the words "brown hair" with a letter "B". The words "crossed with" will be an "X" and "gives" will be an "=".

So the statement will read as: B X B = B. Isn't that easier and faster?

Now, to make things even more confusing, there is this dominant/recessive thing going on. Now, the best way to think of this is as a dominant person being more powerful and thus over rides the submissive (recessive) person's ability to express his or herself. This is kind of like that older brother who thinks he's boss.

To express a dominant trait, we use a capital letter. A recessive trait is symbolized by the lower case letter. One letter represents each gene, or allele. Let's say you have brown hair, thus your symbol would be "B". Both your parents have brown hair, so they are both "B" as well. Where did sister come from? You ask. Remember, alleles are in pairs. So in actuality, both your parents have "Bb", one letter for each allele, or gene. The "B" shows that they have the dominant brown hair, but the recessive "b" shows that they can (and did) produce a blonde child. Only one allele is needed to express the dominant case. So only one "B" is needed to show dominance while both alleles, "bb", are needed are needed to express the recessive trait.

This time the equation looks more like this: Bb X Bb = B_ (you) and bb (sis)
The underscore is a short way of writing down all the possible genotype combinations that result in the same phenotype.

I belive that most of you have heard of a Punnett Square? Well, get used ot it. Here is High (Middle?) School Biology all over again.

♀ \ ♂	**B**	**b**
B	**BB**	**Bb**
b	**Bb**	**bb**

You can see that the father submits one allele for each chromosome, a "B" and a "b", the top row. The mother does the same thing, the far left column. If you cross each allele as if using a times table, you get 4 possible genotypes. The "BB" is brown hair and since both alleles are a capital "B", this means the individual is homozygous for brown hair and thus can only produce brown haired offspring. The "bb" is homozygous for blonde hair. This individual can only produce blonde hair. The other 2 are the same, "Bb". These individuals are brown haired, but carry the blonde gene and so are heterozygous.

Since the phenotype of the BB and the Bb individuals are the same, we can use the underscore "_" to signify all brown haired individuals as "B_" instead of writing down every genotype that codes for that same phenotype; BB, Bb and Bb.

Okay, enough of that. Let's get down to the business of fish. If you understand what I said above, then this should be easy.

CAMBODIAN

To me, the easiest of the traits to describe is the cambodian gene. This is the gene that causes a fish to have colored fins yet to be either colorless or have be greatly reduced in color on the body. A good example of the cambodian is the tradtional, or red, cambodian. Here is a picture of a red cambodian female betta.

Betta Bunnies
ST Red Cambodian Female

As you can see, she has virtually no color in her body, but has bright red fins. The cambodain trait is a recessive trait. This means it requires both alleles to give you the cambodian fish. First you have to identify the trait, in this case it is cambodian. Now assign it a symbol, we'll use the letter "c". Since the cambodian gene is recessive, this means the letter "c" will be lower case to represent the trait being present and the "C" to mean the dominant solid colored fish.

A homozygote non-cambodian would be "CC"
A homozygote cambodian would be "cc"
A heterozygote cambodain would be "Cc"

A non-cambodain crossed with a cambodian is re-written as: CC X cc
Father submits 2 alleles, "C" and "C"
Mother submits 2 alleles, "c" and "c"

Punnett Square:

♀ \ ♂	C	C
c	Cc	Cc
c	Cc	Cc

From this type of cross, all of the offspring will be solid colored. This is referred to as the F1 generation, or first generation cross. Now if you were to bred brother to sister from this litter. You know from above that they both carry the cambodian trait. So cross the F1 generation. Cc X Cc.
Father submits 2 alleles, "C" and "c"
Mother submits 2 alleles, "C" and "c"

Punnett Square:

♀ \ ♂	C	c
C	CC	Cc
c	Cc	cc

Now you get a litter that produces 3 of 4 squares as solid colored, otherwise known as 3/4 or 75%. The rest of the litter, 1/4 or 25%, is cambodian. This second generation cross is known as the F2 cross. Now that you have some cambodians and you want a litter that throws all cambodains, all you need to do is select a male and a female cambodian and breed them. Viola!! A litter of nothing but cambodians.

DOUBLE TAIL

A nice thing about genetics, once the basics are understood, it is only a matter of repetition. The double tail trait is very similar to that of the cambodian trait in the fact that is also a recessive trait. A fish needs both recessive alleles to be a double tail and only one dominant allele to be a single tail.

Betta Bunnies Double Tail Steel Male

First you need to identify the trait - double tail
Second you need to assign a symbol - DT for the single tail and dt for the double tail

I have a single tail male whom I thought carried the double tail gene. His genotype would then be DT_. DT means he is dominant for being single tail, his phenotype or how he looks is single tail, and the "_" means I really did not know what he carried. Since I wasn't sure if he was dt or not, I used "?" in the box to signify that I was not really sure. I bred this male to a female who is double tail, so her genotype is dtdt. So the statement would be DT_ X dtdt.

Punnett Square:

♀ \ ♂	DT	?
dt	DTdt	DTdt
dt	DTdt	DTdt

As you can see, there were no double tails in the litter. By following the rules of dominance, the DT means that the fish is single tail, not double tail. The double tail will be coded only by a "dtdt". Since there is no "dtdt" in the square, that means the male betta is homozygous dominant for single tail, or "DTDT". This particular type of cross is called a "test-cross." This means you use a homozygous recessive animal to cross with an unknown and use the phenotypes of what you get to determine the genotype of the unknown. Confused yet? All of the babies carry the double tail gene, due to having a double tail mother. If you cross this F1 generation, this is what you'd get. DTdt X DTdt.

Punnett Square:

♀ \ ♂	DT	dt
DT	DTDT	DTdt
dt	DTdt	dtdt

This second generation, or F2, will produce both double tails and single tails. Of the four squares, 2 are "DTdt," 1 is "dtdt" and 1 is "DTDT." That is three of four squares, which is 3/4, which equals 75% of the litter being single tail and the other quarter, or 25%, is double tail.

YELLOW

This trait is another one that I have discovered through my own experince that is recessive. But instead of using "Y" for red and "y" for yellow, the term "NR" for "non-red" is used. So a red fish is "NR" which is domimant over the "nr", or yellow, fish. Many breeders believe that there is a second trait, a "NR2", that supposedly determines orange, but the genetics are still new and need not be discussed here at this time.

Betta Bunnies ST Veil Yellow Male

Trait = Yellow
Symbol = NR is dominant (red) and nr is recessive (yellow)

Cross: nrnr yellow male X NR_ red female
Punnett Square:

♀ \ ♂	nr	nr
NR	NRnr	NRnr
?	NRnr	NRnr

Again, this cross results in all of the fry having the same genotype and thus the same phenotype, they are all red. Because of what I got, I can state that the red female is a homozygous dominant red fish, or "NRNR". I crossed this F1 generation to get the F2 generation, NRnr X NRnr. Here is what happened.

Punnett Square:

♀ \ ♂	NR	nr
NR	NRNR	NRnr
nr	NRnr	nrnr

Here I have 75% of the litter that are red and 25% of the litter that are homozygous yellow. Of those red fish, 1/3 are homozygous for red and the rest are heterozygous for both colors.

BLACK

For the ease of explaination, I am going to refer to any fish that is black as a black. The melano thing isn't even going to be mentioned here, except to state that this is where the letter "M" came to be known as the symbol for blacks. A black fish is what you see, a black fish. The black color trait acts the same way as above, it is a recessive gene and thus needs two alleles to be expressed. You breed a pair of fish that carry the black trait, and you'll end up with a litter that has black fish. Thus, how I ended up with blacks in the first place. Two steel blues crossed together gave me blacks, what a wonderful and gorgeous, surprise.

Betta Bunnies Delta HM geno
Black Male 7MM8 01/22/00

The trait is black, the symbol is "M" for dominant and "m" for recessive. The cross was a pair that had steel as their irridescent color, both of whom carried the black gene. Mm X Mm.

Punnett Square:

♀ \ ♂	M	m
M	MM	Mm
m	Mm	mm

Here, 25% of the litter are homozygous for black. The other three-quarters, or 75%, have the irridescent steel body color. Of the steels, 1/3 are homozygous dominant for only steel, no black. The rest are heterozygous for black.

GREEN, BLUE, & STEEL BLUE

Just when you thought you knew something, a wrench is thrown in. This case is quite different as there is no true recessive trait. They are all dominant, so they "share" or are "co-dominant". This means that each color acts upon the other equally to produce their own color. In such cases, you can get a litter that is all one color, a litter that produces the two colors or all three possible colors in one litter. Here is how it goes.

Turquoise Green Male
Owned by Beautiful Bettas (betta5)

Blue HM male
Owned by Kay Prien

Betta Bunnies Half Moon Steel Male

We will symbolize this trait as Bl, which will stand for blue. I don't know why we don't use "G" for green. That letter is not used in betta genetics as far as I can tell, but this is what the books use. So to make things more difficult, the "Bl" represents the blue, the green and the steel blue irridescent colors. It breaks down like this:

BlBl - green
Blbl - blue
blbl - steel

Here you can see that both the "Bl" and the "bl" have equal say in the color of the fish. If "Bl" were to be dominant, then the "Blbl" would also be a green fish, not blue. Thus, the crosses are such that steel (blbl) X steel (blbl) gives 100% steel (blbl). This is because no matter what you do, the only alleles each parent can submit is "bl" and thus can only pair with "bl". The green trait is the same way. You cross a green "BlBl" X green "BlBl" and you'll get 100% green "BlBl".

The blue color is quite different. Because the blue has both alleles represented by both parents, the result is all three colors. The percentages of each color vary. You won't get the same number of greens as blues as steels. Blbl X Blbl.

Punnett Square:

♀ \ ♂	Bl	bl
Bl	BlBl	Blbl
bl	Blbl	blbl

Here you see that 2 squares of 4, or 50%, are blue. Of the other two squares, each contains a different genotype, thus you have 1/4, or 25%, each of steel and green. Isn't genetics wonderful? Now, to make matters interesting, if you cross a green to a blue, you will get 50% green and 50% blue. If you cross a blue to a steel, you'll get 50% blue and 50% steel. Lastly, if you cross a green to a steel, guess what you'll get?

Punnett Square:

Blue X Steel

♀ \ ♂	Bl	bl
bl	Blbl	blbl
bl	Blbl	blbl

50% Blue
50% Steel

Blue X Green

♀ \ ♂	Bl	bl
Bl	BlBl	Blbl
Bl	BlBl	Blbl

50% Blue
50% Green

Steel X Green

♀ \ ♂	bl	bl
Bl	Blbl	Blbl
Bl	Blbl	Blbl

100% Blue

You guessed it, neither color of the parents. So, if you wanted greens and steels, don't breed those two colors together.

DIHYBRID (or two trait) CROSSES

What we have been discussing during all of the above are crosses involving one trait. Double tail, yellow, black, cambodian and even the irridescent colors. When dealing with only one trait, you are dealing with monohybrid crosses. Mono meaning one, or single. Now we are going to work with dihybrid crosses, meaning two traits at the same time. I will only deal with two different dihybrid crosses. Things can get really hairy with trihybrid, three traits at once, and polyhybrid traits of more than three at a time. I'll leave that to the experts.

The first dihybrid cross we'll do is a solid colored red male with a yellow cambodian female. The symbols used are "NR", "nr, "C" and "c". The red male's genotype was CCNRNR. The yellow cambodian female's genotyope was ccnrnr.

CCNRNR X ccnrnr

Since all the alleles the male can submit are dominant alleles and all the alleles the female can submit are recessive, we'll skip this punnett square and state that all offspring produced will be solid colored red fish; CcNRnr. Now we'll do a F1 generation cross, CcNRnr X CcNRnr.

Punnett Square:

♀ \ ♂	CNR	Cnr	cNR	cnr
CNR	CCNRNR	CCNRnr	CcNRNR	CcNRnr
Cnr	CCNRnr	CCnrnr	CcNRnr	Ccnrnr
cNR	CcNRNR	CcNRnr	ccNRNR	ccNRnr
cnr	CcNRnr	Ccnrnr	ccNRnr	ccnrnr

WOW!! That was a lot, wasn't it? Instead of a simple 4 square Punnett, we jumped up to a 16 square one. Why? Because each parent now has four alleles, two for each trait. Since you are talking about both parents who have 4 alleles to submit, you get 4 x 4 which equals 16 possible genotypic combinations. Now for the fun part, figuring out which genotype represents which phenotype.

Here are the genotype and what they code for:

CCNRNR - solid body red
CCNRnr - solid body red
CCnrnr - solid body yellow
CcNRNR - solid body red
CcNRnr - solid body red
Ccnrnr - solid body yellow
ccNRNR - cambodian red
ccNRnr - cambdian red
ccnrnr - cambodian yellow

You get 9/16, or about 56% solid red fish. There are 4/16, or 25%, of both the solid yellow and red cambodians and finally 1/16, or about 6% yellow cambodians. As for determining which red fish carries the yellow gene, you can't tell from just looking. You'll have to breed it to a yellow to find out.

One last combination of fish, probably one of the most sought after crosses as black females are usually sterile. A black with steel irridescence bred to a steel carrying the black gene. Actually, this one is easy compared to the above cross. The black male with steel irridescence has the genotype blblmm and can donate only "blm" for both it's alleles. The female is a steel carrying black and her genotype would be blblMm. She can submit "blM" and "blm".

blblmm X blblMm

Punnett Square:

♀ \ ♂	blm	blm
blM	blblMm	blblMm
blm	blblmm	blblmm

This cross produced 50% black and 50% steel.

I hope you have enjoyed this attempt at betta genetics. I have tried to include the basic ideas and several examples of what can happen when breeding bettas. This is not even close by any means the possible combinations of colors and color patterns that one can find. Feel free to comment or add suggestions by e-mailng me at dynarb@yahoo.com. Thank you for your visit and hope you come back soon.

Some common betta symbols and their interpretations

dt = double tail, recessive
p = protruding fin rays (combtail), recessive
b = bright (or blonde), dominant
c = cambodian, recessive
m = melano (black), recessive
er = extended red, partially dominant
vf = varigated fins (butterfly), recessive
nr = non-red (yellow), recessive
bl = blue, green or steel, co-dominant
si = spread irridocyte, dominant
op = opaque, partially dominant
mb= marble, recessive

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