INDIAN CORN AND MARBLE BETTAS
By Steve Saunders

Although not generally available in the pet shops, one of the most popular strains of Bettas in IBC today is the marble Betta. The fish of this strain are characteristically blotchy, piebald or marbled in appearance; their bodies possess patches of dark on light color or vice versa. The colours are generally black (melano), blue, green, steel blue or recently red on white: although some tri-color marbles exist and can be produced. These are usually red, white and some other dark colour.

One interesting fact about the marble Betta is its origin. Jim Sonnier (1975) claims that Walt Maurus apparently procured the strain from an inmate of a correctional institution, Mr. Orville Gully just prior to 1972. The fact that Mr. Gully was able to produce an entirely new strain of Betta without a huge fish room shows that one can do a lot with Bettas in very little space.

The IBC Judging Standards (Revised 1983) defines the marble Betta as "… also variegated, but different than the butterfly. Here the key factor is the body, which must show a mixture of dark and light – a marbleized pattern. A dark bodied fish with a white face (piebald) or a light bodied fish with areas of contrasting color, such as red, is typical. The Betta must be literally spotted; he may be half one color and half another; whatever his pattern, his body must show the marbled effect."

Betta breeders know that within a spawn of marbles not all the fish will possess a marble pattern. Generally the fry start life appearing to be either a dark bodied solid color or light bodied solid color Betta but as they grow a contrasting color may appear in slowly growing spots or patches. Some fish never develop the secondary color and do not look marbled. The currently proposed revised IBC Judging Standards alludes to this fact stating "Cellophane Bettas, - the transparent effect- though of marble origin, are not permitted in the marble class.

To date we still do not understand the mechanisms for the inheritance of the marble trait in Bettas… although some theories have been proposed. This article has been written to discuss this trait and to propose a new theory to explain the inheritance of the trait based upon the jumping gene or transposable genetic element theory.

<u>SOME BACKGROUND</u>
What are the characteristics of marble strains of Bettas …

(1) Marble Betta spawns inevitably consist of dark bodied solid colored, light bodied solid colored, and marble patterned fish. The marble pattern may be good or poor.
(2) Spawns of either light bodied solid colour or dark bodied solid colour Bettas from marble stock will produce some marble, some solid color and some variegated fish.
(3) If the "marble genes" are introduced into a stock of true breeding solid color fish then it becomes extremely difficult for the breeder to return his stock to the pure breeding solid colour type. The fish generally seems to always throw some marbles or parti-colour fish.
(4) A cross of a marble stock fish of one colour type can produce the marble affect in the color of a fish of a non marble type.

CURRENT THEORIES

Despite the interest in the strain, very little is understood about the inheritance of the marble characteristic. At the 1984 IBC Convention in Oklahoma, I asked Dr. Gene Lucas about the mechanism of the inheritance of the marble characteristic, but Gene could only tell me no one knows. Jim Sonnier (1975a,b) was among the first breeders to try to come to grips with the problem of marble genetics. He listed the "types" as "fertile black", "white face", marble and cellophane. However Sonnier was not able to explain the inheritance of these characteristics.

For years bettaphiles talked of cellophanes and fertile blacks which appear to have been simply genotypic marble Bettas that do not conform with the IBC Standards for marble bettas. Faith Sizemore (1985) gave her theories on "marble inheritance" which was based on an interaction of several genes and "gene sets" – the "piebald gene", spotting, red-loss and zoning. Faith then believes that the interaction of multiple genes is responsible for the trait. However, Hesson and Smith (1982) considered "the marble as a variably dominant genetic trait, much the same as butterflies." Their theory is that the characteristic is inherited from one gene only (Mendelian) but fish inheriting the gene may or may not express it in a way apparent to us. They further pointed out that crossing marble Bettas to solid colored strains of Bettas resulted in some marbles.

Whatever the mechanism of inheritance, the marbling pattern is not unique to Bettas. In the hands of breeders marble type strains have been developed in other species of aquarium fish- marble angel, *Pterophyllum scalare*; calico goldfish, *Carassius auratus auratus*; chocolate chip or marble mollies, *Poecilia latipinna*; piebald swordtails, *Xiphiphorus helleri* to name a few. All these fish exhibit instability of the color patterns, the uniqueness of each individual fish's pattern for these species. Naturally occurring populations of fish with marble characteristics similar to bettas exists, notably some of the morphs of African rift lake cichlids and some populations of North and Central American livebearers, Family Poecilidae. It remains to be seen if the mechanism of marble inheritance of these fish is similar to that of bettas.

THE "JUMPING GENE THEORY"

One of the most recent fundamental discoveries in the science of genetics is the existence of "transposable elements" also known as "jumping genes." Apparently there are certain genes which are capable of moving from one location to another on an organism's chromosomes. Sometimes they will insert in places where they interfere with gene expression. This results in a cell's and its daughter cells' inability to perform certain tasks associated with that gene. Because the "jumping genes" residence at a particular place in the chromosome is only temporary, the inability of the gene interfering to express itself is only temporary.

Before going on to explain this phenomenon further and how it applies to bettas, I would just like to point out that "jumping genes" or "transposable genetic elements" have been shown to exist in a number of organisms. Transposable genetic elements have been studied extensively in bacteria. For example the bacterial genes responsible for anti-biotic resistance are encoded on transposable genetic elements. Genetic engineering, the new science that we hear so much about, has convince the bacterium *E. coli* to produce human insulin using transposable genetic elements. Transposable genetic elements have been found in yeast. One of the current theories on human antibodies is based upon transposable genetic elements.

In higher organisms, transposable genetic elements were first studied in maize or corn. Some of the variegation in Indian corn (the decorative maize with multi-color kernels) can be attributed to transposable genetic elements. In corn each kernel represents an individual of the next

generation. It's a convenient system for a geneticist to work with since one can sit down with a few kernels of corn and count the phenotypes of a cross and gain an accurate statistical result. (Fedoroff 1984).

Some of the varieties of Indian Corn have kernels that bear a remarkable resemblance to the color patterns of marble bettas! Even the names of the marble-like variations of kernels - spotted and dotted for instance sound like names applicable to marble bettas. Like variation of the patterned fish in a marble betta spawn, not all sibling kernels on a cob of Indian Corn will exhibit the marble-like characteristic. Some are light solid colored others are dark solid colored.

How does the system work with bettas? If a jumping gene is present and it inserts itself into a gene responsible for producing a black (melano) pigment, it stops the production of black (melano), and all the progeny cells (a clone of cells) will be unable to produce black (melano). This results in a non-black patch appearing; looking like a white or cellophane patch. The reverse can happen too! If the cells are unable to produce black (melano) because the transposable genetic element is present, and the element leaves then the progeny of this cell (a clone of cells) will be able to produce black (melano) again (reverts) and a black (melano) patch will appear.

It's easy to see that if you can make a patch work of dark spots on a light betta or light spots on a dark betta you'll soon have a marble betta! Sometimes a dark blotch on a light colored marble betta will develop a light spot in the center. (A sort of bulls-eye effect.) This can easily be explained if you think of a clone of growing cells which first cannot produce black (melano) because of the inserted jumping gene (the light background of the fish), the jumping gene later leaves the affected melano producing gene in the growing betta allowing black (melano) production (the dark blotch) and in later growth a re-insertion of the jumping gene affecting the melanin production in a smaller group of cells within resulting in an inner light spot in the dark blotch.

The "jumping gene" theory can also explain why some marbles never marble. If the jumping gene does not insert (in the case of a dark bodied fish) or leave (in the case of light bodied fish) in any of the cells during the life or growth period of the fish then marbling will not take place. Now this also could work with other pigments… the ability to produce green, blue, steel blue and red pigments. The jumping genes would just insert themselves into genes that produce these pigments turning on or off the pigment producing ability of multiplying cells in the growing fish.

RED MARBLES

The inheritance strain of red marble bettas that I am currently working upon could be explained using this theory. I began by breeding a red-red-white butterfly male to a black and white marble female. The first generation produced some red and white marbles, as the "jumping gene" for marble interfered with the production and or distribution of red pigment. Some black and white marbles were produced as well as red black and white; apparently the gene was inserted in two locations where it could interfere with both the red and the black (melano) pigment. This is consistent with the transposable genetic element theories since the gene jumps around during DNA replication… and extra copies could be produced. Also some red individuals were produced… apparently all black (melano) pigment production was arrested while red was not interfered with. Others were cellophane types… the red and black (melano) pigment production was apparently stopped because of the insertion of the jumping genes in both.

I've used the best red and white marbles for subsequent spawns but these spawns have not been true breeding… in the red and white sense. Black and white as well as red, black and white individuals have resulted. This is because even if the fish does not appear to have any red, it may be that the black (melano) genes are suppressed by the jumping genes in the parents, but the jumping genes leave the black (melano) genes in the offspring… allowing the production of black (melano) pigment again.

CONCLUSIONS

Admittedly the above explanations for transposable genetic elements or "jumping genes" has been simplified. Jumping genes may exert their effects on control genes as well as functional genes. The way they influence control genes is more complex but essentially the model is applicable to the marble variety of *Betta splendens*.

There is much evidence that jumping genes or transposable genetic elements may be responsible for the characteristic known as marble in bettas. The inheritance of the marble characteristic can be explained by this theory. But proving this theory could be difficult.

It is interesting to note that so many diseases that medical science is wrestling with today, notably cancer, involve the mysterious turning on and off of genes… producing small clones of aberrant cells, known as tumors in cancer. The clones of aberrant cells may resemble clones of dark or light cells in marble bettas. Could it be that marble bettas hold a key to understanding these diseases?

There is one thing for certain. Whether or not you're interested in the genetics of marble bettas, and whatever the mechanism of inheritance may be, marble bettas are beautiful. And we can all enjoy that!

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