Guppy Color Strains

Philip Shaddock

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Contents

Preface

This book has been twelve years in the making and has had previous incarnations.

It now includes over 150 strains. It's accuracy, in terms of correctly identifying the genes involved in each of the strains, has been steadily improving because I have done many of the crosses myself.

My goal throughout the last twelve years is to provide guppy breeders with a reliable reference source. Some will use the collection to identify guppies they acquired but whose genetics they do not know. Others will use the book to find out how to breed specific strains. Some strains can be fairly complex and require basic knowledge of their genotype to maintain them. Still others will use the book to find strains they are interested in breeding.

The guppy breeder interested in crossing experiments will find that many combinations of color genes have already been created and refined. I have grouped many variants of basic strains together to make the collection useful. For example, you can see what a White Half-Black Pastel looks like, then the blond white and yellow variants.

I have also provided a lot of breeding tips for specific strains, including tips for developing specific strains for the judging bench. Where the gene makeup of the strain is complex I provide basic information about how to keep all those genes intact.

Classification System

There is no good way to absolutely categorize guppies into strains, where a **strain** is defined as a truebreeding guppy that produces sons and daughters that are 80% similar. An example is a Panda Moscow, a guppy with both Moscow with the Pink mutations (*Fig.1*).

The Panda belongs to both Moscow and Pink categories.

In loosely grouping guppies in this book, I start off with a rule that says certain strains have dominant traits that are strictly Y-linked.

The Moscow is a case in point. The Moscow defining characteristics are strongly Y-linked, meaning they are passed on from father to son and not to daughters. So I have grouped all guppies that have the Moscow Y-linked supergene together as a family of strains.

Fig.1 Panda Moscow. Photo by Finn Bindeballe

Then there is the "Blond Glass Belly Panda," which combines the blond, Glass Belly, Pink and Moscow mutations (*Fig.2*). This is a guppy that belongs to three different categories. I know it is entirely arbitrary, but I think of the Blond and Glass Belly traits as "modifier" traits because they are autosomal and tend to affect the whole body uniformly. So I have made the Blond Glass Belly Panda a variant of the Panda and the Panda is grouped with the Pink mutation guppies.

The Color Strains book has split many of the old groupings into smaller groupings. For example, the Mg (Metallic Gold) gene has now got its own chapter.

I have nothing to recommend my arbitrary classifications other than the fact that they may be of some use to breeders examining strains of unknown genotype. Or more simply the classification system makes this book easier to read from beginning to end. In fact fancy guppies are usually an arbitrary concoction of genes, selected for aesthetic appeal and perpetuated through the habit of selective breeding and the assignment of such names as "Flamenco Dancer."

There are so-called "base body" classification systems. Classification

systems like these have to do with **phenotype**, *what you see*. My work with the microscope examining color on the cellular level shows that what you think you see with your naked eye is not necessarily what you actually see with the aid of the microscope. The microscope is much more accurate. And if you had tools that could make observations on the molecular level, your observations would be that much more accurate again. Good theories rest on accurate observations. The designer is interested in **genotype**, the actual genes that are determining the appearance of the guppy.

Fig. 2 Glass Belly Panda. Photo: Philip Shaddock

I record the genotype for many of the strains in this book. Ultimately this is the most accurate way to identify guppies.

You will find a guide to the system of notation I use for genotype in Appendix A: Gene Symbols.

I recommend that you buy *The Theory and Practice of Guppy Breeding* as a companion to this book. It will make understanding the genetics sections a lot easier. And I include a wide array of breeding strategies and advice on designing breeding programs. Neither book stands on its own.

Acknowledgements

I would like to thank the photographers for their excellent photo-

graphs, filling in many of the gaps in this enormous collection of strains.

I would also like to thank those who I quote in the text for their contributions. For those who have shared their knowledge freely I am truly grateful.

1 Moscows

Moscows originate from Russia, arriving in East Germany and then spreading around the world from there.

The first Moscows to find their way to Germany looked like what we now call "Metal Heads."

Today the name Moscow is usually applied to solid blue Moscows.

My good friend and fellow guppy breeder Franz Peter Schaffarth, sent me a rough translation of an article written by the German breeder Gernot Kaden about the history of the Moscow. It makes interesting reading.

Mr. Kaden identifies two different strains of Moscow. There is the version that has a blue front of the body and a filigree (snakeskin) peduncle, and the version that is solid dark blue. The filigree Moscow arrived in Germany in 1980, with the solid version occurring ten years later. Mr. Kaden notes that the filigree snakeskin pattern was an intense red and yellow covering the peduncle and tail fins, just like the picture above.

Mr. Kaden tells us the German breeder H. Schillat attended a Moscow guppy show in 1980, bringing back the filigree guppy. However, he only brought back males.

All the filigree Moscow variants that followed were achieved by crossing to females with dominant colors on the X-chromosome. Mr. Kaden singles out D. Sammet as the creator of a beautiful red filigree Moscow version through crossing with a female with a red color gene.

The filigree Moscow guppy was a big hit among East European breeders. It spread throughout East Germany, Poland and CSSR (Czechoslovak Socialist Republic).

Mr. Kaden tells us that the first all-blue variant was first shown in 1990 at a Berlin DGF (German Guppy Federation) show. The exhibitor was Hungarian. The blue was so intense that they showed it in the blue class. Mr. Kaden tells us the intense blue was the result of mating with females with blue color genes. These females actually show blue color in the fins and the body, especially in the front of the body. So that is another helpful guide for the Blue Moscow designer: choose females that show a lot of blue.

Mr. Kaden says the monochrome blue variant often has a golden (European gold, U.S. bronze, Asia tiger) version as part of the strain's genotype.

Nomenclature. The Moscow with a half-snake body goes by several names: Metal Head Snakes, Moscow Snakeskins, Russian Metal Head Cobra and so on.

The Moscow in the Rest of the World

The strain's introduction to Japan is chronicled in Tsutsui's Guppy

Base Book Vol. 1. In an article titled "Moscow Blue" beginning on page 16, Tsutsui wrote: "I was able to obtain this strain in the autumn (October 29th) of 1996. After I acclimatized it to my tanks, I saw that it was very special. I was very curious about Moscow Blues because I had no idea of their genetic make-up. Mimbon Aquarium in Germany originally shipped the first Blue Moscow to a Japanese wholesaler."

The Moscow first arrived in America at a north U.S. IFGA guppy show around 2000. It generated a lot of excitement, going for auction well over U.S. $200. It was shared and distributed all over the U.S. by the auction winners.

The Moscow that first made it out of the city by that name to Eastern Germany was actually what we now call a "Metal Head." It had a snakeskin pattern on its peduncle and in its fins. Is this the same guppy strain discussed in the 1971 article? We may never know.

Moscow Color and Genetics

Although the stock from which modern Moscows were developed were half-body snakeskin, today the Moscow is popularly considered to be a solid-colored guppy, including a colored head. The Blue Moscow is the most common form, although the Green Moscow is also plentiful. Blue and Green Moscows are essentially the same. Green Moscows just have a lot of yellow color cells in the top layer of the dermis. Purple Moscows have plentiful red color cells. Some breeders have even developed the Red Moscow.

The other common characteristic of Moscows is a black component to the color. This causes variation in Moscow apparent coloring from light blue (or other pigment color) to a dark version of that color. The black component can become so dark as to produce a Black Moscow. However, true Black Moscows have been developed using half-black and three-quarter black guppies. A difference between Moscows and such Black Moscows as Onyx and Midnight blacks is that Moscow females are normal colored and not black.

What sets apart "normal" Moscow black is its highly motile pigment, meaning the black pigment aggregates to the center of the cell and or disperses to the cell periphery. This gives the Moscow its famous chameleon quality, where it can vary from a light grey to a much darker black. Midnight Black Moscows do not tend to have this motile black color. They never lose the deep blackness of their color. What this suggests is that the black of Blue Moscows is a different

mutation affecting black color cells then that found in Midnight Black Moscows.

In fact, in my book "Guppy Color Manual" I identify the highly Y-linked Moscow gene as the key gene that sets Moscows apart. It allows the front of the body to come under the influence of black (and other) modifying genes. This is why you can so easily develop Moscow color variations, from solid blacks, to greens, purples, reds and a variety of metal colors.

The Moscow is famous for its colored head, although other strains can have colored heads. (Full Platinums, for example, can have white heads.) Add to this the fact that you can have a Moscow without a colored head! The only sure way of classifying a fish as a Moscow is to know its descent from a Moscow forefather.

In the many crosses I have done, I have found the common Moscow phenotype, solid blue, can be easily modified, as you will see in the varieties listed for this category. This makes me wonder how many Moscow strains are out there under other names!

In crosses between Blue Moscows and other strains you often see the blue metallic color in F1 males in the area of the head, the upper half of the front of the body and some blue spotting in the caudal fin. (See the spots on the caudal fin of the Blond Blue Moscow below.) As I just noted, this is due to completely or strictly Y-linked genes that form a supergene. It appears to be close to the SDR (sex determination region) because there has not been a confirmed case of a female who passes on the trait to her sons or daughters. Midnight Black females, which have a black head, and are often offered as X-linked Moscows are due to the Midnight gene and not the Moscow Y-linked gene. The rest of the body can be influenced by X-linked genes, which is normal for guppies and not in fact a Moscow trait.

It is incorrect to say that a "Blue Moscow" is due to a single gene. A number of genes are required to create the solid blue color. Even the metal head and front of the body can come under different color gene control, producing silver headed Moscows, for example.

It is also incorrect to say there is "an additional black gene" in Moscows. Claus and Ramona Oche in Germany have postulated a MBEG (Moscow Black Extra Gene) gene for this color. It may be autosomal recessive. In fact the Y-linked Moscow gene allows the front of the body to be colored, which means that the same gene that gives a half-black guppy its black peduncle can color the front of a Moscow black as well. It is the Y-linked Moscow gene that creates

an all-black guppy, not an "extra gene." Recently Jim Alderson, the American guppy breeder, declared that there is an autosomal Moscow gene. But again, this is not a Moscow-specific gene, this is a gene that is common to all guppies. It just happens to express itself differently on the Moscow because of the Y-linked gene. See my "Guppy Color Manual for a full discussion of the Moscow gene.

Breeding the Moscow

The genotype for the basic Moscow is: XY^{Mw}. You can only produce Moscows from Moscow males, not Moscow females. The reason? Guppy males have X and Y sex chromosomes, while females have two X chromosomes. So only males have the Y chromosome. Since the Moscow gene is tightly linked to the Y-chromosome (it cannot cross over to the X chromosome), it is always passed to sons by fathers and never to daughters. This is the most basic observation you can make about guppy genetics, and was in fact the first, made by Johannes Schmidt in a scientific paper around 1920!

Since the Moscow Y-linked gene applies only to the front of the body, the rest of the body is under normal genetic influence. There is in fact nothing special about the second half of the Moscow body in terms of color genetics, despite what breeders like Osche or Kaden might say.

However, because there is no genetic Moscow females (females do not have the Y-linked Moscow gene), and only Moscow males can produce Moscow sons, to "color" a Moscow, you have to use another Moscow strain or an outcross strain that has color on the X chromosome of the female to change your strain's color. For example, you can use an American solid blue to alter the blue color of your Moscow strain.

The solid color Moscows are particularly good to use in crosses. In crossing to Magentas, Stoerzbach Metals, American Half-Black greens with the Onyx allele and Pink guppies, I have been able to create an incredible variety of strains while keeping them cross-compatible.

Difficult to see in solid color Moscows is red spots on the peduncle. When solid Moscows have the golden mutation (called Bronze in the U.S., tiger in Asia and Gold in Europe) the presence of red spots is revealed.

Blue Moscow

Hawaiian Blue Moscow bred and photographed by Philip Shaddock

Genetics

The guppy pictured here has genetics typical of Blue Moscows, that is a Y-linked Moscow gene and X-linked blue genes. To modify the blue color, outcross to an American solid blue delta, or another strain with a lot of blue color.

The Blue Moscow has a black layer of color cells underneath a blue-light reflecting iridophore layer. See the Color Manual for how the Tyndal Blue effect works. What this means is that black modifier genes and iridophore modifying genes will affect the depth and intensity of blue.

Good outcross females to modify the blue include American blues and Japanese blue strains.

Albino Blue Moscow

Albino Blue Moscow. Photo and guppy by ATFG.

This is a Blue Moscow with the albino gene. Notice how pale the blue is when you remove the black layer genetically. A good plan to enhance the blue color in grey Blues would be to breed albino Blue Moscows for blue color and then cross to a grey Blue strain.

Blond Blue Moscow

Luke Roebuck's Blond Moscow

The blond Moscow shown here is a version of the Blue Moscow with the blond gene. It has a light yellow body. Notice the spots in the caudal fin. These are actually iridophores (metal color cells) not black color cells.

Genetics
The blond Moscow shown above is erroneously called a "Gold Moscow" in the U.S. and Asia. That's because the mutation name is "blond" not "gold."

This particular Blond Moscow was from Tomoko Young's fish room. She originally acquired the strain from Jim Heller. She crossed it into Micariffs to enhance the yellow. Notice the red spot in the peduncle area. This is a very common feature of the Moscow.

The genotype for this guppy is:

XY^{Mw} bb

Where Mw = Moscow, b = blond

Asian Blau Blue Moscow

Asian Blau Moscow. Guppy and photo Philip Shaddock

This Blue Moscow variant has no red color cells and has an overall greenish blue color.

Genetics
The red color cells in the body are converted to iridescent blue, giving

the strain its bluish green color. A Blue Moscow was used to create this strain. You can see an intense blue area at the bottom of the peduncle. This is where a red spot on the parental strain is located.

The genotype is: XY^{Mw} AbAb

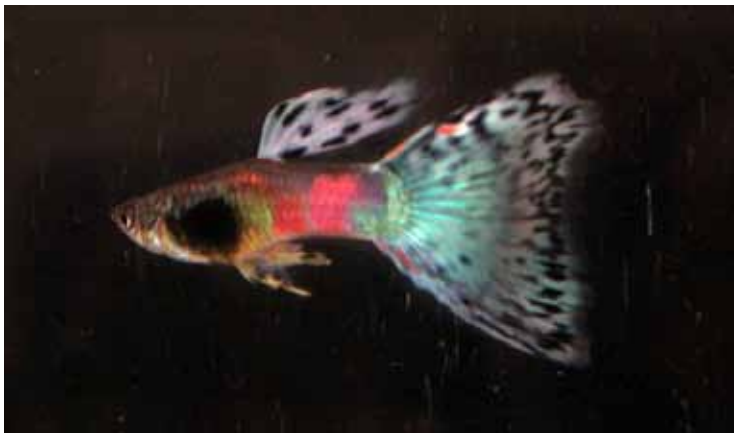
Where Mw = Moscow, Ab = Asian Blau

Golden Blue Moscow

This is the golden version (called Bronze in the U.S., Tiger Moscow in Asia, gold in Europe) of the Blue Moscow. Typical are the red spots on the peduncle and the spotted fins. The females have a pronounced reticulation pattern.

Genetics

The Golden Moscow is a Moscow homozygous for the golden (gg) gene. The golden gene is often found in strains to make the strain darker.



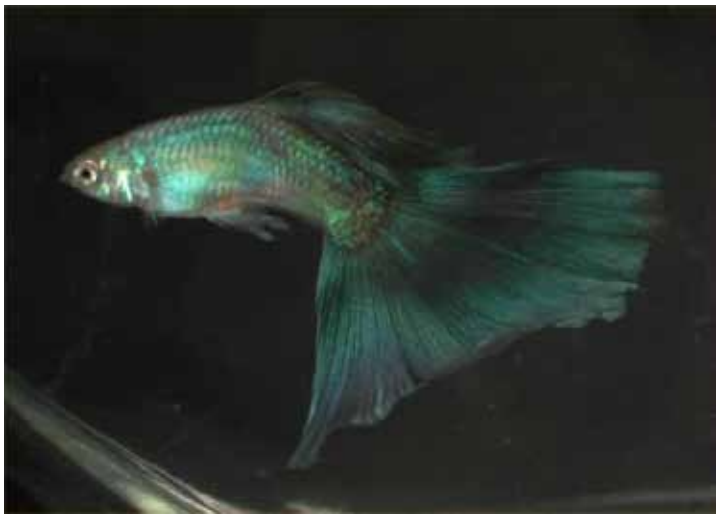
Golden Moscow by Philip Shaddock

The gene appears to have been present in the Blue Moscow that originated out of Germany. (Based on an account provided in Yoshiki Tsutsui's *Guppy Base Book Vol. 1*).

The dotted pattern in the fins is an interesting effect of the golden gene, which results in the aggregation into spots of melanophores in the fins. It is similar in phenotype to the spotted patterns on snakeskin strains.

See the Guppy Color Manual for an in-depth discussion of the effect of the golden gene on black in guppies and particularly in Moscows.

Green Moscow



Green Moscow (Philip Shaddock photo)

This green version of the solid Moscow is simply a Blue Moscow with an increased number of yellow color cells. This color is found in all Blue Moscow drops, at least to some degree. Crossing with American solid greens (or other green strains) will bias the color to green.

Purple Moscow

Purple Moscow. Picture by Kerry Collier

Create a purple Moscow by outcrossing to an American purple delta.

Full Red Moscow

Red Moscow. Picture courtesy of ATFG. This male has the high dorsal gene as well.

Moscow Red. Guppy by Hiroshi Nishimura. Bluish coloring comes from the Moscow. It is from a cross between a Blue Moscow male and American Full Red female.

A Full Red Moscow is sometimes difficult to distinguish from a Full Red guppy. You have to be in possession of the guppy's ancestry to make the judgement, although in some strains bluish metallic color indicates Moscow heritage.

A Full Red Moscow is Y-linked for the Moscow gene and X-linked for Full Red. It is created by crossing these two strains. Presumably the red color gene can cross over to the Y chromosome to create a Full Red Moscow with the key genes on the Y chromosome.

A strategy for creating Red Moscows from other Moscows is to maintain two strains, the Moscow strain and Full Red strain X-linked for the Full Red gene. (X-linked females will display red color in their fins and at the top of their peduncles.) Maintain the Full Red females pure while constantly outcrossing the Moscow strain until it has become pure Full Red.

Half-Black Red Moscow

Moscow HB Red. Guppy by Takahiro Mizuguchi.

Takahiro Mizuguchi, who has been working with Moscows since the mid-nineties, says the original Blue Moscow strain he acquired came out of Eastern Europe. He says there was a lot of red color pigment in the original import stock. Crossing red guppies into the Blue Moscow enhanced the red pigment. Crossing with American delta blues fades out the red.

I do not particularly like this version of the Full Red.

Albino Full Red Moscow

Albino Red Moscow. Guppy and photo: Oscar Inostroza

This version of the Red Moscow has an intense red coloration with a solid red caudal and dorsal fin.

Another photo of the Albino Red Moscow

Oscar Inostroza, a breeder of red guppies in Canada, was experimenting with crosses with his red albinos, intent on discovering their genetics. One of the crosses he attempted was to a Moscow imported from Taiwan, billed as a Purple Moscow. In fact the strain was probably a Midnight Black Moscow, one with the Midnight allele.

You can see some bluish highlights, an indication this is a recent cross.

Golden Red Moscow

Golden Red Moscow

This strain combines the Moscow, Golden and Full Red genes.

Midnight Black Moscow

Black Moscow. Photo: Philip Shaddock

There are various strains that go by the name of "Black Moscow." However what distinguishes the strain shown in the picture above is the density and purity of the black and the fact that this strain does not have the "chameleon" quality of the usual Moscows. It is always constantly black, and does not fade to grey. It does not have the same degree of blue or green metallic color as Blue (or other solid) Moscows, but is rather a dull black.

This particular version of the strain has the long dorsal (the elongated allele or Fa).

Females have a dark reticulation pattern. This is different from Moscows where females are quite a bit lighter. Females have black heads, which confuses many breeders into believing she is X-linked for the Moscow gene. But my own crosses show that her sons do not inherit the Moscow gene.

Genetics

In a crossing experiment, I found that the trait is autosomal co-dominant. In a first generation of a cross to a Blue Hawaiian strain, the first generation has half-strength black and the second generation of the cross was full strength black.

The gene involved in the blackening of this guppy is called the "midnight" gene. It is autsomal recessive. The genotype of the Midnight Black Moscow is:

XY^{Mw} midmid

Where Mw = Moscow and Mid =Midnight

Contrary to what some think, the Midnight gene is not particular to the Moscow. It can be incorporated in other strains to darken the black component of their color. But it will not be fully expressed in the front of the body.

Midnight strains tend to have health and fertility problems.

Albino Midnight Black

Albino Midnight Black. Photo by Gene Orlowski

Female Albino Midnight Black. Photo by Gene Orlowski

What is interesting about this version of the Midnight Black is the bronze color and greenish metallic color. The blue component in the metal color is due to an iridophore modifier gene that normally plays a role in the blue metal color of Blue Moscows.

Golden Midnight Black

Golden Midnight Black

The golden gene is often found in strains of Midnight Black Moscows. The golden gene is reputed to make the color darker.

Half Black Moscow

Two tone Onyx Black Moscow. Guppy and photo by Philip Shaddock

The Half Black Moscow has a very dark body that does not fade. The black on the body tends to be a duller, bluer black than regular Moscow Blues. The fact that the black does not fade indicates that it is a different black modifier gene then the Moscow black gene. It is undoubtedly the gene that colors the half-black body area in half-blacks. It is autosomal. I have given the gene the name "Onyx" to distinguish it from the sex-linked half-black gene. (Dr. Berríos originally came up with this name.)

The guppy pictured above came out of a cross between a Hawaiian Blue male and a HB Green female. He is an F2 generation male.

The cross produced both dark fin males and light fin males. All the females have dark fins. The picture illustrating this entry shows a light fin Onyx. At this point in its development, the fins are more yellow and black than green or blue. These are colors that come from both sides of the cross.

Body Genetics

The particular version of the half-black Moscow is very black. The deep blackness of this strain is inherited from the original female mother (Half-Black Green). The deep blackness of the females suggests that the HB Green line had the NII variation of the half-black allele. (See the *Guppy Color Manual*.)

The half-black gene seems to help make the guppy more black than a non-half-black Moscow. However, the blackness may not be *entirely* due to the half-black gene, as an autosomal gene making the guppy black (MBEG) may contribute to the darkness. See the *Midnight Black Moscow* entry for a discussion of the genetics of a similar Black Moscow imported from Thailand.

It is probably the case that the fins appear to be lighter because they are contrasted against a very dark body. However, with that said, it is true that the fins are under the influence of separate color genes. See the *Leopard Moscow* entry for a Moscow with snakeskin fins.

Stoerzbach Moscow

Mature Stoerzbach Moscow. Guppy and Photo Philip Shaddock

Young Stoerzbach Moscow. This is the same guppy as shown above. Guppy and photo Philip Shaddock.

The strain has two types, a yellow version and a yellow green version. Both versions become green metallic when they mature. The yellow color seen in this strain may be from the original Blue Moscow strain.

Genetics

This strain descended from a cross between a guppy with the Stoerzbach autosomal recessive gene and a Blue Moscow.

What's interesting about this cross is that the Blue Moscow pheno-

type is almost entirely lost, including the colored Moscow head. The genotype of this strain is:

XY^{Mw} ss

Where Mw = Moscow; ss= Stoerzbach

Pink White Moscow

Pink White Moscow. Guppy and Photo by Philip Shaddock. 3.5 Months Old

Female with the Pink White trait at the base of the caudal fin.

This Moscow variant is a combination of the Blue Moscow and Pink White genes. The Hawaiian Blue Moscow heritage is shown in the blue green metallic color of its front of the body, and the black or metallic streaking in its caudal fin. Both males and females have the characteristic Pink White trait, a white area at the base of the peduncle and caudal fin.

The shape and location of the red spot in the peduncle of the male is a marker for its descent from a Hawaiian Blue male.

Genetics

This cross also shows that the Pink White trait is dominant, since the inbred Blue line definitely does not have the pink white trait. The F1 cross proves that the Pink White mutation is not the same as the Pink mutation, which is autosomal recessive and therefore would not show up in the first generation of a cross.

So the putative genotype of the F1 generation of the cross is:

$X^{Pw}\ Y^{Mw}$

Where Pw = Pink White; Mw = Moscow

Full Gold Moscow

Full Gold Moscow

This strain is a cross between a Moscow male and a Full Platinum

female guppy. The goal of the cross was to produce a White Moscow.

The guppy is phenotypically very similar to the Full Platinum guppy, with its white leucophore base color and overlaying Metallic Gold color.

Genetics

Like the Full Platinum, it has a gene coloring the fins white, the white saddle gene coloring its dorsal and the platinum body gene coloring its body. What makes it different is its white head.

The genotype is:

$X^{Mg\ Ws\ Ni\ Wt}\ Y^{Mw}$

Where Ni= half-black; Wt = White tail; Mw = Moscow; Mg = Metallic Gold; Ws = White Saddle

Blue Grass Moscow

The guppy essentially has a Moscow body with Grass fins. The Grass Nike stripe may also be influencing the body. See the next entry, "Leopard Moscow," for a guppy with a very similar genotype.

Genetics

This is one of the crosses that Japanese breeders have made with the Moscow. In this case it is a cross between a Japanese female grass guppy and a male blue Moscow.

Blue Grass Moscow. Picture by Luke Roebuck

Luke Roebuck comments on the Japanese origin of the name (Shadow Dancer) of this Moscow variation: "Sometimes the bodies become so black when the males are in mating condition that, against a black background, the fish almost disappears (camouflages) against the background, except for the brightly colored and contrasting fins. What you see is brightly colored variegated fins dancing around the tank!"

Luke comments on the genetics: "A cross between a Moscow male and any kind of leopard/grass female will eventually lead to a variation of what the Japanese call "Shadow Dancer" in their Full Metal Blue Glass Strains. Willi Kosa in Germany also has been developing Moscow Leopards which are a different form of "Shadow Dancer." They don't have Blue color in their fins. Since the name Shadow Dancer is not genetic-based and derived from the specific cross of the Moscows and Blue Glass, Japanese breeders don't usually extend this name to the other variations. However the genetic name Full Metal Glass or Leopard remains basically the same. Only the colors vary. This is strictly my opinion."

"I have some pictures of the Shadow Dancers and Willi Kosa's website has pictures of the Full Metal Leopards which have yellow/white color base in the fins and very dark bodies. They are not related to the Blue Glass or Japanese Shadow Dancers, but have compatible and "analogous" breeding color genetics. Sometimes it is best to understand how some strain names are derived so as to be able to correlate the strain with other possible compatible variations."

The genotype for this strain is:

$X^{Gra}\,Y^{Mw}$

Where Gra = grass, Mw = Moscow

Leopard (Grass) Moscow

This is probably the strain developed by Willi Kosa in Europe.

The guppy has a Moscow blue body and Grass spotted fins.

Genetics

The Moscow body colors and fin colors are due to different genes. This guppy definitively demonstrates this. I produced a black Moscow with green fins and there are other examples in the following entries.

The gene influencing the fins is probably the Grass gene so the geno-

type of this guppy is putatively:

$X^{Gra}Y^{Mw}$

Where Gra = grass; Mw = Moscow.

Leopard Moscow. Photo by Finn Bindeballe.

It is possible that the grass fin gene (Gra) is on the Y-chromosome or on both sex chromosomes.

Carnation Moscow

This guppy is F1 of a cross between a Midnight Black Moscow and a Blue Grass guppy.

A breeder originally from Russia, Tigranes Karapetyan, posted on the Guppy Designer facebook page a picture of what he called a "Carnation Moscow."

F1 Red Grass Moscow. Guppy and photo by Philip Shaddock

The two phenotypes are obviously very similar.

Moscow Fire Tail

Prasertsak Komolchan, ATFG .Moscow Fire Tail

This guppy appears to be a combination of the Midnight Black Moscow and the Full Red. The Full Red body color may be suppressed or lost entirely. The contrast in colors is striking.

WREA Full Pearl Moscow

WREA Full Pearl Moscow. Prasertsak Komolchan, ATFG .

Prasertsak told me this was a mutation out of a Midnight Black line.

2 Metal Heads

Metal heads are simply a combination of the snakeskin and Moscow genes. The name "Metal Head" refers to the metallic head on Blue Moscows. However, the entire front of the body is actually under the domain of the Moscow Y-linked gene. (See the chapter on Moscows for the nature of the Moscow gene.) The snakeskin pattern is expressed in the rest of the body. You often see the "Metal Head" name reduced to "Metal" on the Internet, as in "Metal Snakeskin."

Metal Head Roundtail. Picture by Finn Bindeballe

The snakeskin pattern can be crude or fine (lace).

The Metal Head Snakeskin is actually quite similar to the original form of the Moscow, as it first appeared out of Russia.

Genetics

The Moscow supergene is completely Y-linked. The snakeskin gene may be Y-linked or X-linked. To create a Metal Head Snakeskin,

cross a male Blue or Green Moscow with a female X-linked snakeskin. (She usually shows a snakeskin pattern to some extent in her fins.)

The color of the front of the body and the quality of the pattern on the rest of the body depend on what strain of Moscow and snakeskin you use in the initial cross so you may need to experiment with various different Moscow and snakeskin strains.

Usually it requires several generations of inbreeding and outcrossing to get a really nice Metal Head as the snakeskin pattern can vary in its penetrance (the degree to which it shows versus the Moscow). The genotype is:

$X^{Sst\ Ssb}Y^{Mw}$

Where Sst = snakeskin fins, Ssb = snakeskin body, Mw = Moscow

The snakeskin gene readily crosses over, and since the snakeskin body and fins genes are close together, a Metal Head strain may be fully Y-linked.

$XY^{Mw\ Sst\ Ssb}$

Because the snakeskin body and fin genes are separate, it is also possible to have other patterns associated with the fins.

I have arbitrarily divided the Metal Heads into Cobra and Lace varieties. See the Snakeskin chapter for more detail on cobra and lace snakeskins.

Cobra Metal Heads

Yellow Cobra Metal Head

Yellow Metal Head Snakeskin by Luke Roebuck

This version has yellow color and a cobra snakeskin pattern.

Red Cobra Metal Head Roundtail

Picture by Finn Bindeballe. From a Danish guppy show.

This guppy combines the red snakeskin, Blue Moscow and the roundtail genes. The putative genetics of the strain are:

$X^{Rdt\ Sst\ Ssb}\ Y^{Rndt\ Mw}$

Where Rdt = Red tail, Sst = snakeskin fins, Ssb = snakeskin body, Rndt = Roundtail, Mw = Moscow

Black Cobra Metal Head

Black Cobra Platinum Metal Head. Guppy and photo by Buncha Silskulsuk.

This guppy has a heavy black color with cobra snakeskin markings and a black Moscow front of body. It combines a Midnight Black guppy with a snakeskin guppy.

Genetics

Here is the putative genotype:

$XY^{Mw\ Ssb\ Sst}$

Where Mw = Moscow, Ssb = Snakeskin body, Sst = Snakeskin Fins

Buncha developed the strain by out crossing a Midnight Moscow with a snakeskin. Because the Midnight gene is autosomal recessive, the deep black color would not have intensified until the second generation.

Although I show the snakeskin genes to be Y-linked, they can also be X-linked.

Red Metal Head Mosaic

The breeder, ATFG, calls this a Metal Red Mosaic. Picture used with permission.

This variation incorporates the fantail and mosaic tail genes and red tail gene. It's putative genetics would be:

$X^{Mo\ Rdt\ Fa}\ Y^{Mw\ Ssb\ Sst}$

Where Mo = mosaic tail, Rdt = red tail, Mw = Moscow, Ssb = snakeskin body, Sst = snakeskin fins, Fa = fantail

Here is another version of this design:

Photo by ATFG.

Lace Metal Heads

Red Lace Metal Head

Red Lace Metal Head. Andrew Lim

The front of the body is a Blue Moscow phenotype, the rest of the body is a Red Lace Snakeskin phenotype.

Orange Metal Head Fantail

Orange Metal Head Fantail. Guppy and photo by ATFG.

This variation has an overall orange color. It has the Asian fantail shape.

Yellow Lace Metal Head Fantail

Yellow Lace Metal Head. Picture and guppy ATFG. This variant has an Asian style fantail caudal fin.

The front of the body is Blue Moscow and the rest of the body is Yellow Lace. The Fantail gene has created the fantail shaped caudal fin.

Yellow Metal Head Doublesword

Moscow Filigran Doublesword. Hans Peter Neuse.

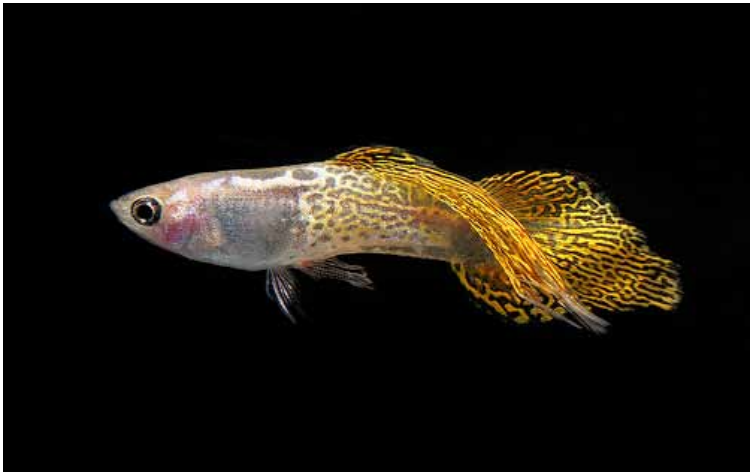
This strain would be known as a filigran in Europe. "Filigran" is a German name for the snakeskin gene.

The guppy combines the Moscow, snakeskin and doublesword traits. The doublesword trait is widely believed to involve both X and Y genes.

The putative genotype for this guppy is: $X^{Ds}Y^{Mw\ Ssb\ Sst\ Ds}$

Where Mw= Moscow; Ssb = Snakeskin body; Sst = Snakeskin fins; Ds = Doublesword

Yellow Lace Metal Head Speartail



Metal Head Yellow Lace Speartail. Andrew Lim

The spear tail shaped is largely determined by X-linked genes, but Y-linked genes also play a part in shaping the spear shape. See the *Guppy Color Manual* for more information on fin genetics.

3 Snakeskins

Snakeskins are guppies with a distinctive pattern on their bodies. The pattern resembles the patterns on snakes. It is a pattern found widely in nature.

Yellow Cobra snakeskin. The vertical bars in the peduncle give this strain its "cobra" moniker.

Figure 1 False Cobra Water Snake. Image is from Wikipedia.

The vertical bar pattern found in some snakeskins is sometimes called "Zebrinus" after the African Zebra. At other times it is called a "cobra" trait. On animals, lines or bars can be vertical or horizontal. A horizontal pattern of lines is found on the small Asian Zebrafish fish *zebra danio*). It is the subject of many ongoing scientific articles.

Common Names

The guppy with a chain link or lace pattern on the body is known by different names around the world.

In Europe it is widely known as "filigran" which is German for "lace" or "filigree." The term filigran is used in Michael Dzwillo's 1959 paper "*Genetische Untersuchungen an Domestizierten Stammen von Lebistes reticulatus (Peters)*." This was the first formal description of the snakeskin.

Previous to the Dzwillo paper, snakeskins were also known as the "English lacetail," and may have descended from those bred by W.G. Phillips, the famous guppy judge and creator of the first modern guppy standard.

In North America it is known as the snakeskin.

In Asia, the terms snakeskin, lace, cobra and king cobra are used. The term "cobra" is widely used to describe a guppy with the vertical pattern in the peduncle. According to the Asian conformance guppy judge Derrick Tan, the defining characteristics of the family are the chain like pattern and vertical bars in the peduncle.

For judging purposes, the tail pattern will determine if the guppy is a snakeskin or lace, with the lace having finer spots, and the coarse snakeskin having larger spots and some finer spots. Apparently the term "king cobra" is applied to snakeskins with black "eye spots" on the body.

In this book I will call a snakeskin with a fine detailed, interconnected pattern a "lace tail" or a "lace guppy" or a "lace snakeskin." If the body also has a coarse pattern I will call it a cobra or coarse pattern snakeskin. I consider the distinction quite arbitrary and only use it for descriptive convenience.

Snakeskin Guppy History

The snakeskin pattern is likely a very ancient one found in guppies. It occurs as discreet patches on guppies in wild populations, and

has persisted in populations introduced into places like Africa and Southeast Asia (for mosquito control) for at least a century and a half. It also found in the guppy's "cousin" the so-called Endler.

Figure 2. Wild "snake" guppy. This photo appears on the University of California, Berkeley website in an educational page on microevolution. ***(http://evolution.berkeley.edu/evosite/evo101/IVB1bInthelab.shtml)****.*

In an online educational article on microevolution, an experiment is described, performed by the famous guppy biologist Dr. John Endler. Over a period of 15 generations, he raised guppies against a pebble bottom, divided into two groups. One group had predators present, the other did not. The ones with the predator present developed large dot patterns. The ones with no predator present developed small dot patterns.

The article author suggests spots evolved on males to serve a dual purpose. One is to attract females and the other is to help camouflage the male against the colorful pebbles on the bottom of the stream. The spots would help make the male guppy harder to see against a background of light and dark pebbles.

There have various claims made about the origins of modern snakeskin guppies. However, the filigree pattern on the body may have been developed and enhanced from tiny patterns on wild guppies that the earliest scientists attributed to what they called "filigran" genes. And the pattern may have developed on the caudal fin before the body, as the earliest pictures of domesticated snakeskins show the pattern on the caudal fin and at the base of the peduncle.

Dzwillo (1959) found the gene to be X-linked. Dzwillo probably got the guppy from the German breeder Dr. Eduard Schmidt-Focke in the 1950s. Dr. Schmidt-Focke got them in turn from W.G. Phillips.

Harald Auer at his Laboratory Strain Guppies website (now defunct) showed a picture of what he described as a very old strain, called Filigran (XY^{Fil}).

Figure 3. Blond Filigran from Harald Auer's Laboratory Strains website.

The Russian geneticist V. S. Kirpichnikov provides an illustration of the filigran in 1981. Note the similarity in the body pattern between the Harald Auer picture and the Kirpichnikov illustration. The fin appears to a "mosaic" style in the Auer picture and a streak style in the Kirpichnikov picture. It appears that the modern chain link pattern is a development of the earlier less organized pattern.

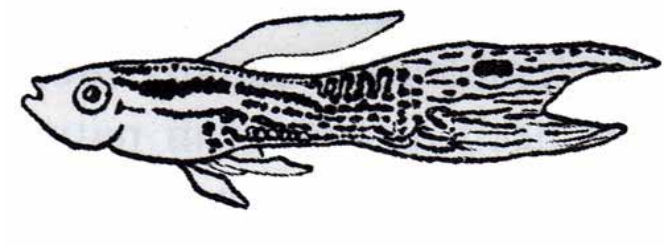


Figure 4. Filigran illustration by Kirpichnikov

In an article on the web ("*Fifteen Years of Snakeskin Topsword Guppies in the UK*," by Alan Charlton, dated 2002), the author states that he first saw snakeskins at a British guppy show (the Fancy Guppy Association's International Show in Manchester) in 1966. They had been at least around since the early 1950s. He believes that W.G. Phillips developed the first "snakeskin" type of guppy, called the Lacetail or

Leopard. They apparently were greenish, with short clear dorsals and coarse snakeskin markings. This description conforms to the pictures we show of the earliest snakeskins.

W.G. Phillips may properly been seen not as the inventor of the snakeskin, but the first breeder to actively select for it and bring it up to show standards.

In *Guppy Handbook* by C.W. Emmens (1970) the author has a picture of a topsword guppy developed by Dr. Eduard Schmidt (who later changed his name to Schmidt-Focke).

The guppy is called a "Lace" topsword guppy. The caption says, referring to the breeder Eduard Schmidt, "It is believed that his fish became the base for the King Cobra and English Lace guppies. "

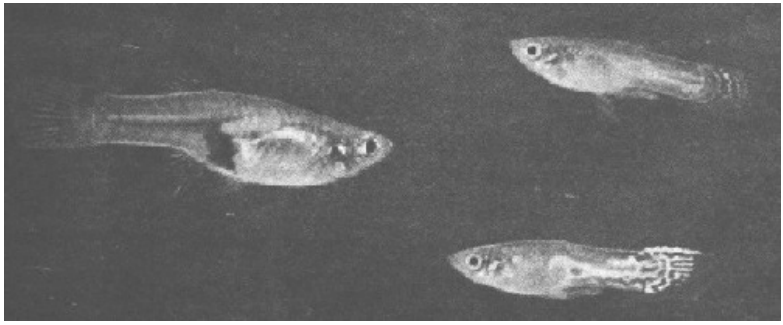


Figure 5. The Phillips Lacetail or Leopard

The same picture appears in *All About Guppies* by Paul Hähnel, dated 1964. Hähnel's comment is: "A male of the German strain of Leopard Guppies, similar in some respects to the Lacetail Guppy. Photo by Dr. Eduard Schmidt."

In fact, we know that the snakeskin guppy Dr. Schmidt-Focke bred came from W.G. Phillips in the mid-1950s because there is an article by Dr. Schmidt-Focke in the July 1964 issue of Tropical Fish Hobbyist in which he states the "Leopard strain came from Mr. Phillips in London." The picture in the article Dr. Schmidt-Focke uses to show what a Leopard guppy looks like is the one shown above.

Charlton refers to the article in T.F.H. (*Tropical Fish Hobbyist* magazine) by Eduard Schmidt, in which he claims that a half-black guppy arose as a mutation from swordtails he had obtained from W.G. Phillips in 1956. His claim is often disputed by breeders in Germany. A visitor to the Guppy Designer forum, Duncan McDonell, who is

old enough to have been around at the time, says that it is likely that Schmidt got what were called "Black Lace" snakeskins from W.G. Phillips. What Duncan was suggesting is that the background color in the Schmidt snakeskins was black. In any event the first scientific description of the half-black pattern occur ed in 1947 (O. Nybelin). (NYBELIN, O. 1947 Ett fall av X-bunden nedärvning hos Lebistes reticulatus (Peters). Zoologiska Bidrag fran Uppsala 25:448-454.)

Mike Reed in the May, 1965 issue of Tropical Fish Hobbyist (TFH p. 69) attributes the "King Cobra Guppy" to the Mac Guppy Hatchery in Long Island City, New York. According to the article, the strain began with a three-quarter black male with "unusual" markings. (This must have been a guppy half-black and snakeskin hybrid.) It was imported by Paul Hähnel and handed to a Mr. Reitz. He worked with it for some time and then passed it on to the Mac Guppy Hatchery. According to the wife of the owner of Mac Guppy Hatchery, Paula Kalichstein, the guppy was named for its King Cobra snake markings. Apparently 55 tanks were devoted to the project over 18 months.

The Pattern

The snakeskin pattern can be described as islands of black color cells (melanophores) in a sea of platinum (iridophores). Figure 6 shows a close-up of the region of skin on a snakeskin spanning the tail (on the left) and peduncle (on the right).

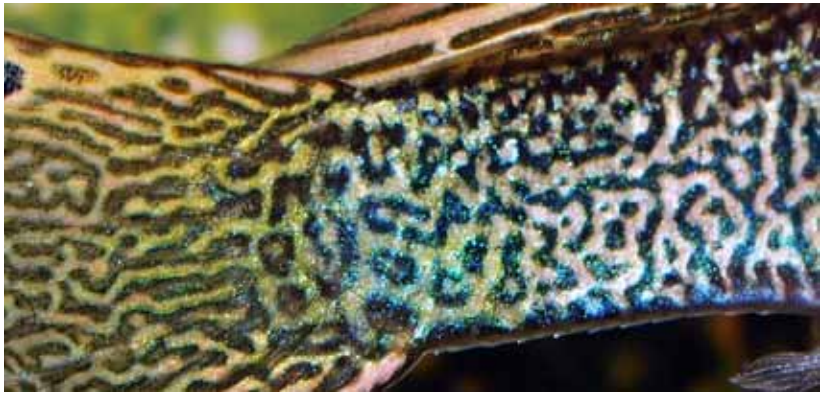


Figure 6. Snakeskin pattern on the tail and the peduncle.

The darker areas are the islands of melanophores and the lighter areas are the iridophores. A microscope image illustrates this even better.

Figure 7. Microscope image of the snakeskin pattern in the tail.

What is dramatically revealed by the microscope image is that the melanophores exist as islands in a sea of melanophores. So in some sense, the snakeskin pattern in the guppy is half-way between a stripe and a spot pattern!

In fact the pattern is due in a large part to the interaction of melanophores (black color cells) and xanthophores (yellow color cells). This is a topic I discuss in depth in the *Guppy Color Manual*.

Snakeskin Variations

Guppy color cells exist in layers, with melanophores at the bottom, iridiphores (light reflecting color cells) in the middle and the yellow and red pigment color cells (xantho-erythrophores) on the topmost layer.

The pigment color cells can give the snakeskin an overall yellow, red, green, black or other color tone The color of the light reflected by iridophores can also affect the color. You see a lot of blue color in the picture above of the snakeskin skin, which means the reflecting iridophores has given this strain a lot of blue color. The blue mixes with

yellow pigment color to give the guppy a green color cast. (Again, see the *Color Manual* for a detailed description of guppy color.)

Because the color cells can be under the influence of so many different genes, snakeskin patterns can be quite variable. The hobby does not really have the language to describe all the possible permutations, both in terms of color or the fineness or coarseness of the pattern, indeed whether it is in a stripe or spot formation.

Figure 8. Yellow Snakeskin. Photo by Philip Shaddock

The names for patterns on caudal fin tail include:

- Mosaic, which is the crudest pattern, often exhibited as irregular vertical lines spreading out from the base of the caudal fin like sound waves. The lines are clearly separated.
- Leopard, where the pattern is large widely spaced spots.
- Grass where the pattern is small, dense spots, sometimes with a clear background (glass).
- Lace where the pattern is very fine as in the guppy shown above.

Figure 9. Lace Snakeskin Photo by Philip Shaddock. This particular strain also has a finely detailed pattern on the body.

Genetics

The snakeskin gene is dominant over the wild type. Female snakeskins crossed with male Moscows have snakeskin peduncles and snakeskin fins and are called "Metal Heads." The half-black gene makes the peduncle area of snakeskins black and the fins become a dot pattern, creating a guppy Asians call the Dragon guppy. The Stoerzbach, Metallic Gold, magenta and possibly other autosomal metal genes cause the snakeskin pattern to be completely or almost completely suppressed, producing a blue or yellow metallic phenotype, often with spotted fins. An example is the Mikariff guppy. (See the chapter on the Mikariff.) The platinum gene and other Y-linked genes affecting iridophores cause a modified snakeskin pattern. Lace patterns become cobra, often with zebrinus bars in the peduncle. The half-tuxedo pattern splits the peduncle area horizontally into a upper half of black and a bottom half of platinum yellow.

The basis for all these changes may be in how these genes affect the interaction of color cells. How color cells interact with each other on close contact is a major determinant of animal patterns. It will be shown that many of the genes that we commonly talk about as pattern genes affect the way color cells repulse, attract or suppress

each other. It is a different way of thinking about guppy patterns, as the cumulative effect of a gene acting on individual color cells, rather than the imposition of order on a group of color cells. It is a bottom-up order, not a top-down order. Once you begin to think about color cells in this way, you have come a long way along the way to mastering the manipulation of these patterns. Think of the snakeskin pattern as a gene that somehow contains the blueprint of a pattern and you become hopelessly lost in your quest.

This does not mean that genes cannot have "domains" of influence. There are separate genes for the snakeskin pattern in the body (Ssb) and the fins (Sst). Because the snakeskin body and fin genes are so close together on the chromosome (i.e. linked), they appear to be inherited as a single gene.

So the proper way to indicate the genetics of snakeskins is this:

$X^{Ssb\ Sst}\ Y$ *Where Ssb = snakeskin body; Sst = Snakeskin fins*

The snakeskin genes can be X- or Y-linked and crosses over frequently.

When the link is broken between the *Ssb* and *Sst* genes, such that they end up on separate chromosomes, you often get different types of "snakeskin-like" patterns on the body and the fins, like Figure 10.

Figure 10. The guppy has a fine lace pattern on the body and a really coarse pattern on the fins.

Indeed the *Ssb* and *Sst* genes can be separated entirely. You can have a snakeskin body and solid color fins, or vice versa. The Japanese Grass

strain may be a solid body guppy with "snakeskin" fins. I put the word snakeskin in quotation marks because the actual genes involved may not be adequately described by the single term "snakeskin" (or "filigran" or "cobra").

Again, the most comprehensive reference here is the Color Manual which goes into a great detail about so-called snakeskin genetics. But I can summarize it here by saying that the idea that patterns in animals are due to single genes has long been shown by scientists to be oversimplified to the point of being incorrect. In fact patterns are due to multiple genes participating in gene networks. Here is an example illustrating what I mean.

Nobody in the hobby would consider the Magenta gene to be a snakeskin gene. Yet the presence of the Magenta mutated gene in a strain causes the snakeskin gene to behave very oddly. It produces a phenotype that varies in the expression of the pattern, like the "Peacock" guppy I produced by crossing a Magenta Moscow with an X-linked snakeskin. The F1 male of the cross is sown in Figure 11.

Figure 11. Peacock guppy, the result of a Magenta Moscow X Snakeskin female cross.

Is the Magenta gene a snakeskin gene? No, but it obviously affects the expression of the snakeskin gene. So the Magenta gene and the snakeskin gene must belong to the same network. This network affects the relationship between the color cells. And the Magenta gene messes up the relationship of color cells in the snakeskin guppy such that this beautiful Peacock phenotype is produced. (The Moscow gene obviously belongs to the same network as well.)

So this brings us back to the discussion of the lace and coarse snakeskin genetics. Is there a "lace" gene? Is there a "coarse" gene?

The Lace Snakeskin Genetics

The lace gene is often described as X-linked. It gives the snakeskin a finely detailed pattern.

$X^{Ssb\ Sst\ La}Y$ *Where La = lace*

If we think in terms of gene networks rather than "pattern genes" then we can easily see that the so-called "lace" gene is gene that belongs to the same network of genes as the so-called "snakeskin" gene. This is a very subtle but necessary distinction. Remember that snakeskin pattern is created by the repulsion of xanthophores and melanophores such that melanophores form into islands in a sea of iridophores. The difference between lace and coarse snakeskin patterns is a question of degree of repulsion. So I think the snakeskin pattern would not form without the lace gene. The lace gene must be an allele (variation) of a gene intimately involved in governing the relationship between melanophores (black color cells) and iridophores (light reflecting color cells).

Zebrinus or Bar Genetics

The bars seen in snakeskins are usually attributed to the Zebrinus gene which is considered autosomal dominant. (See the Cobra strains below.) An example is the Yellow Cobra Snakeskin shown earlier in Figure 8.

$X^{Ssb\ Sst}Y\ Ze/-$ *Where Ze = Zebrinus*

Since guppies with the bar pattern in the peduncle often show up in snakeskin strains, and a strain can produce both barred and unbarred males, it must be the case that the Zebrinus pattern is similar to the Lace pattern in being due to a gene that affects the relationship between melanophores and iridophores. Of course, in modern genetic terms, the correct way of saying this is that the Zebrinus gene most code for an allele that affects the relationship between melanophores and xanthophores, and that allele is part of a network of genes affecting the contact between color cells at the local level. There is no Zebrinus gene that creates a bar pattern on the peduncle in a top-down fashion.

Violet Phang, a scientist in Singapore studying guppy genetics, published a paper describing the vertical pattern in snakeskin strains as

the "bar" gene. She describes it as autosomal recessive. (See "Interaction between the Autosomal Recessive bar Gene and the Y-Linked Snakeskin Body (Ssb) Pattern Gene in the Guppy, Poecilia reticulata" in Zoological Science 1999 Volume: 16, Issue: 6, Pages: 905-908.)

Is this the same gene as the Zebrinus gene, which is autosomal dominant? That is a good question. The Zebrinus gene is expressed on non-snakeskin strains. Is the bar gene expressed apart from the snakeskin pattern (Ssb)? Can we assume that the two genes involve the same basic genes, but may differ in one or two? "Probably" is the best guess right now.

Yellow Cobra Snakeskin Roundtail

Blond Red Fin Snakeskin Roundtail. Picture by Finn Bindeballe

The primary body color is yellow. The fins appear to be under the influence of red fin genes.

Genetics

The guppy in the picture above incorporates the blond gene, the snakeskin genes (body and fins) and possibly the red tail gene.

$X^{Ssb\ Sst\ Rndt\ Rdt}\ Y\ bb$

Where Ssb = snakeskin body; Sst = Snakeskin fins, Rdnt = Rountail, b = blond, Rdt = Red tail

Albino Yellow Cobra Snakeskin

Albino Yellow Snakeskin. Photo by Andrew Lim

The Asian name for this guppy is RREA Yellow Cobra. RREA stands for "Real Red Eye Albino." It is essentially a yellow snakeskin with the albino gene.

Blond Snakeskin Speartail

This strain incorporates the speartail fin shape. It also has the blond mutation.

Golden Cobra Speartail. Andrew Lim

Black Snakeskin

Black Snakeskin. Courtesy Buncha Silskulsuk.

What distinguishes this version of the snakeskin is the jet black "background" to the snakeskin pattern, indicating the presence of a lot of melanophores (black color cells). In fact the black is not a background color, but rather the melanophores exist as islands surrounded

by a sea of platinum.

Notice that the female has black fins.

Genetics

The black snakeskin is the result of a cross with a Midnight Black Moscow. The autosomal black gene is enhancing the black pigment in melanophores.

Speartail Snakeskin Saddleback

The guppy has a half-tuxedo (*aka* saddleback) pattern, meaning the top half of the peduncle, from the dorsal to the base of the caudal fin, is black while the bottom half is yellow platinum.

There also appears to be black in the dorsal area of the front of the body.

The division of the peduncle into a top half of black and a bottom half of yellow platinum is a peculiar rearrangement of the snakeskin iridophore and melanophore relationship.

Picture by Finn Bindeballe at a Danish guppy show.

Yellow Cobra Snakeskin

This is the classic cobra snakeskin pattern, with coarse markings on the body, a vertical pattern in the peduncle and a coarse snakeskin pattern in the caudal fin.

It is usually yellow, green or bluish green. The "black eye" markings on the front of the body are typical. So is the yellow platinum color in the front of the body.

Genetics

This phenotype is very similar to the Galaxy, which is a combination of the Schimmelpfennig Platinum Sword, snakeskin and lace genes. The difference is there does not appear to be a "bandit marking" (area of dark blue) where the Schimmelpfennig Platinum gene is strongly expressed at the front of the body. Instead there is a strong yellow platinum color.

Yellow Cobra Snakeskin.

Cobra Snakeskin Doublesword

This is a cobra phenotype in a European doublesword.

What is interesting about this particular guppy is that it is expressing the Emerald Green Iridescent gene, and the snakeskin gene at the same time.

The putative genetics of this strain is:

$X^{Sst\ Ssb\ Ds}\ Y^{Ds\ SmIr}$

Where Sst = snakeskin fins, Ssb = snakeskin body, Ds = doublesword X and Y genes, A = Japan Blue

The black area in the front of the body may be a bandit marking.

Doublesword Japan Blue Snakeskin. Photo by Finn Bindeballe from the Dansk Guppy Club, fall 2007

Lace Snakeskin Upper Sword

Upper Sword Snakeskin. Photo taken at a Danish guppy show by Finn Bindeballe

The snakeskin has an upper sword. The background to the snakeskin pattern appears to be due to the Emerald Green Iridescent (EGI) gene. It is possible this guppy is a cross between a snakeskin guppy and a Vienna Emerald Green guppy.

Genetics
This guppy has both the gene for the snakeskin body (Ssb) and fins (Sst).

Green Lace Snakeskin

The Green Lace Snakeskin has a very fine, tight lace pattern. Compare it to the Cobras. I call it both a Green and a Yellow Snakeskin because the same drop of guppies can contain predominantly yellow, green or blue morphs.

Green / Yellow Lace Snakeskin. Photo by Philip Shaddock Luke Roebuck was the source. He called it a "Kaden Lace Snakeskin."

In this particular case the EGI (Emerald Green Iridescent) gene is also present, giving the guppy an overall bluish cast, especially as the base of the peduncle.

Yellow Mosaic Snakeskin

This is an example of a snakeskin with a lace body and mosaic fins.

Yellow Moscaic Snakeskin

Purple Snakeskin

Purple Snakeskin. Guppy and photo ATFG.

Purple is a relatively rare color in guppies.

Blue Half-Moon Snakeskin

ATFG Blue Half-Moon Snakeskin

The blue snakeskin is relatively rare, as yellow pigment usually makes the guppy look green.

This particular strain has the half-moon caudal fin pattern.

Red Lace Snakeskin

ATFG's High Dorsal Red Lace Snakeskin. This is the grey version. This strain includes the high

dorsal gene.

Picture by Philip Shaddock. This is an albino red lace snakeskin.

The red lace snakeskin is often a medium-to-large-bodied snakeskin. The caudal fin and the matching dorsal are burnt orange or orange-red and covered with a very fine lace pattern. The lace pattern is so fine that from a distance these fish appear to be solid color. Females are typically grey-bodied with a completely clear, un-patterned caudal fin and dorsal. The dorsal has the slightest hint of blue while a slight red hue dresses up the caudal fin. Females are very stocky, and perhaps because of this their sons have a tendency to become "chesty."

Apparently some Red Lace Snakeskin strains sometimes throw an "old rose" phenotype:

Old Rose phenotype. Picture by Buncha Silskulsuk.

Glass Belly Red Lace Snakeskin Swallow

ATFG Glass Belly Red Snakeskin Swallow

ATFG has added the glass belly gene to a Red Lace Snakeskin which also has the swallow gene modifying its fins.

Ribbon Red Roundtail

This guppy shows how exotic looking a guppy can become when a number of genes are combined. It includes the lace snakeskin, ribbon, red color and roundtail genes.

Andrew Lim's Ribbon Red Lace Roundtail.

It's putative genetics are:

$XY^{Ssb\ Sst\ Rdt\ Rndt}$ RibRib

Where Ssb = snakeskin body; Sst: snakeskin tail, Rndt = roundtail, Rib = Ribbon fins

Red Snakeskin Roundtail

Snakeskin Roundtail. Photo Finn Bindeballe

This appears to be a roundtail with the red tail gene.

Full Gold Snakeskin

Full Gold Snakeskin. Guppy and photo by Philip Shaddock

This a combination of the metallic gold gene and the snakeskin genes. The Metallic Gold (Mg) gene appears to be dominant, but there is a partial expression of the snakeskin gene. This guppy came out of a cross I did between an X-linked cobra snakeskin and an Albino Full Gold female.

Genetics

Since this was a single male with this phenotype in the F2 of the cross, I assume it was a cross over, and that is maybe why the snakeskin phenotype is partially expressed. It would therefore have the putative genetics:

$XY^{Mg\ Ssb\ Sst}$

Where Mg = metallic gold; Ssb = snakeskin body, Sst = snakeskin fins

4 Magentas

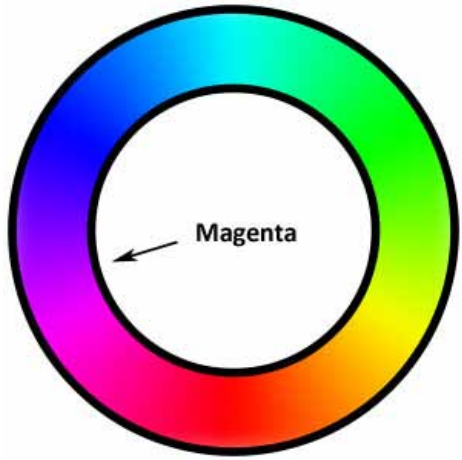
The Magenta gene was first discovered in a strain that combines the gene with the Moscow gene, the Flamenco Dancer. It was discovered by the Thailand fish farm Siam Trade Co and first made available in 2003. The strain apparently originated from a guppy imported from Romania and crossed into a local Thai strain.

A particularly striking example of the use of the Magenta gene to create guppy beauty. Guppy and photo by my friend Dr. José René Meléndez Berríos.

Magenta is a mutation, not a strain. It is like "albino," a color modifier gene. One of the striking aspects of this mutation is that yellow color cells develop early and then become red as the strain matures. This tends to make guppies that have a yellow basis quite orange when they mature.

The hue of the magenta color will also depend on what type of red color cell pigments are present (pteridine or carotenoid) and the density of the blue iridophores and the density of the red color cells. This

color wheel shows how the quality of magenta changes from purple to magenta depending on how you mix blue and red light.



Magenta on the color wheel.

One of the reasons why the Blue Moscow shows a lot of purple or magenta color is the presence of lots of blue iridophores in the skin. (The blue color of Blue Moscows is due to blue light-reflecting iridophores.) The more blue the Moscow is, and the more red color cells it has, the more intense the Magenta mutation becomes. The color is also due to the amount of yellow that is converted to red. Thus in a drop you can have a variation from little magenta to a lot.

When a snakeskin strain incorporates the Magenta gene the Magenta gene creates a blue metallic guppy with spotted fins. There can also be individuals who partially express the snakeskin pattern in the body.

Genetics

The gene is autosomal dominant (M/-). This means the Magenta phenotype emerges in the first generation of a cross. All that is required for its expression is a single allele.

The Magenta gene affects the length of the fins. This suggests that the gene directly or indirectly affects the iridophores.

Long Fin Silverado

Long Fin Silverado. Photo and Guppy by Philip Shaddock

Short Fin Silverado

Short Fin Silverado Photo and guppy Philip Shaddock

This is a strain I developed using strains incorporating the Blue Moscow, Magenta and Metallic Gold genes. The Silverado has a profusion of silver iridophores with varying degrees of magenta coloring.

Shown are the long fin and short fin versions. These were brothers.

The strain descended from a Full Gold Flamenco Dancer imported from Singapore. The female was bred to an Hawaiian Blue Moscow. The Moscow had a Metallic Gold (Mg) gene. In about 1 in 50 fry, a Silverado male was born. They were selected and inbred to produce the Silverado phenotype.

Genetics

The Metallic Gold (Mg) gene produces a combination of silver iridophores and yellow color cells. The Magenta gene then removes the yellow color cells. A silver iridophore guppy results.

It's genotype is as follows:

$X^{Mg}Y^{Mw}$ M/-

Where Mg = Metallic Gold, Mw = Moscow, M = Magenta

It is possible that the Mg gene has to be homozygous, and that is why there is such a low number of Silverados in the first or second generation of the cross. So the actual genotype may be:

$X^{Mg}Y^{Mg\ Mw}$ M/-

Where Mg = Metallic Gold, Mw = Moscow, M = Magenta

Blue Silverado

Blue Silverado. Photo and Guppy by Philip Shaddock

This guppy is a very similar in phenotype to the Flamenco Dancer. However it appears to have white leucophores and lacks the red fins of the Flamenco Dancer.

I call it a Blue Silverado.

This was a young male (six months old). It's fins did not grow much longer.

The cross is relatively short finned because the Magenta gene affects the length of the fins.

Full Gold Magenta Moscow

Guppy and Photo: Philip Shaddock. The guppy is only 2 1/2 months old.

The guppy looks similar to a Full Gold Leucophore, except for the pink tones and shortened fins due to the Magenta gene. This guppy grew up with a lot of yellow color. The Magenta gene converts yellow color cells to red color cells when the guppy is adult.

In the picture is shown an albino male and a grey female.

Genetics

This strain is descended from a series of crosses involving a male BlueMoscow strain, a Flamenco Dancer and a later outcross to a

female albino Full Platinum (known as a RREA Full Platinum in Asia).

The guppy has the following genotype:

X^{Mg} Y^{Mw} aa M/-

Where Mg = Metallic gold; Mw = Moscow, M = Magenta The dash indicates the strain can be heterozygous or homozygous for the Magenta allele, since the Magenta allele is autosomal dominant.

Blond Magenta Moscow

Young Blond Magenta Moscow (2.5 months). Philip Shaddock

This is a Magenta Moscow with the blond allele (called gold in the U.S.).

Genetics

The genotype for this strain is:

XY^{Mw} bb M/-

Where Mw = Moscow, b = blond, M = Magenta. The dash indicates the strain can be heterozygous or homozygous for the Magenta allele, since the Magenta allele is autosomal dominant.

Albino Full Red Magenta (Pink)

RREA Full Red Magentas by Hans-Peter Neuse

The Magenta Full Red is the result of incorporating the Magenta gene into a Full Red guppy strain. The guppy has an overall magenta hue. The Full Red Magenta is sometimes called the "Pink Guppy." But this confuses it with guppies with the Pink mutation.

Genetics

The version developed by Hans-Peter Neuse also has the albino gene in it. He developed his version from crosses between the European Flamenco Dancer and his own RREA Full Red guppy.

Albino Metallic Magenta Ribbon

ATFG's RREA Metallic Pink Ribbon

This guppy appears is a combination of the Albino, Magenta, Full Red, and a metal gene. It has ribbon fins.

It is another fine example of the skills of Asian breeders in combining multiple genes into a beautiful guppy design.

Flamenco Dancer

The Flamenco Dancer is a name given to the gene combination: Magenta + Moscow. The Flamenco Dancer has a blue to purple metallic body and red mottled fins. The strain has poor shaped fins. The poor fin shape must be due to the Magenta allele's color interaction in the fins.

Flamenco Dancer (Franz Peter Schaffarth)

Genetics

The key to understanding the color of this strain is found in the introduction to this chapter. Basically the magenta color is a combination of blue iridophores and orangey red color cells. Yellow color cells are converted to orangey red. Some other red color cells may also be present. In Franz Peter's strain there is fewer red color cells in the body and more blue iridophores. The reverse is true of the fins.

The Flamenco Dancer is basically a Blue Moscow with the Magenta autosomal dominant gene.

$X\ Y^{Mw}\ M/-$

Where Mw = Moscow supergene, M = Magenta gene

Franz Peter strain may also have the red fin gene.

Peacock

This guppy incorporates the Magenta and snakeskin genes. The two genes are both expressed to different degrees in areas of the body. There is snakeskin on the belly and fins. The fins express both the snakeskin pattern and the red magenta color. There is red magenta color across the top of the guppy.

Magenta Peacock. Guppy and photo by Philip Shaddock

I created this strain by crossing a Blue Moscow male with a Silverado female with the Magenta gene. There will males that were almost completely blue with snakeskin pattern in the fins, and males like the one above.

See the introduction to the snakeskin chapter for a discussion of the relationship between the Magenta and snakeskin genes.

Magenta Metal Lace Cobra

Magenta Metal Lace Cobra. Guppy and picture by Junichi Ito

You would never guess this is a snakeskin. But there is a clue. See the magenta color showing on the guppy's back? The Japanese breeder of this fish, Junichi Ito, tells me that without the Magenta gene this guppy appears as a metal lace snakeskin.

5 Medusas and Galaxies

The Medusas and Galaxies combine the Schimmelpfennig Platinum (Sc) gene and snakeskin genes.

The original Japanese Galaxy was created by Yoshiki Tsutsui, although a Medusa was created around about the same time from the same type of strains.

The Medusa phenotype resulting from a cross between a Schimmelpfennig Platinum male and snakeskin female.

I have done this cross and discovered that a Medusa phenotype appears in the first generation of the cross. It has the genotype:

$X^{La\ Ssb\ Sst}Y^{Sc}$

Where La = lace; Ssb = Snakeskin body; Sst = Snakeskin fins; Sc = Schimmelpfennig Platinum

The vertical stripe pattern also appears in the peduncle. I believe this trait is part of the snakeskin complex of genes that is masked by the lace gene. (See the Snakeskin chapter regarding the lace and Zebrinus genes.)

Tsutsui said that the Galaxy was the result of a crossover. So the crossover of one or more snakeskin genes, or the lace gene, may be the key to Galaxy genetics.

I have written a very thorough discussion about my crossing experiments in quest of producing the Galaxy guppy phenotype. It was published as a scientific article for the journal AACL (Aquaculture, Aquarium, Conservation and Legislation). It can be found on the web by entering "Deciphering the Galaxy Guppy phenotype" + AACL as your search terms.

It is a case history in identifying and reproducing well-known guppy phenotypes.

Medusa

Japanese Medusa Swordtail. Guppy and photo by Junichi Ito

Medusa. Photo by Stefano Bressan

This guppy has a similar phenotype to the *Galaxy.* However the caudal fin of the Medusa usually has a mixed pattern, a little of the

pattern from each of the founding strains. Also the body can have the same "calico cat" mix of patterns. Perhaps a better name for this guppy is "Calico Guppy." The first picture shows a sword version of the Medusa, but the delta tail is more common. Also the caudal fin can have different patterns, suggesting there are some genetic variations of this strain.

Genetics

The Medusa is the result of the crossing of a Y-linked Schimmelpfennig Platinum Sword (Schim) and an X-linked lace snakeskin. (However the cross going the other way would presumably work as well.) It is possible to have a calico body and lace fins and vice versa.

Presumably the lace gene for the body can cross over to the Y-chromosome, leaving the lace gene for the tail on the X-chromosome. Then the lace gene on the X-chromosome can be lost in a further outcrossing. This would account for some variation seen in Medusas. It is actually very difficult to identify Medusas on the basis of their appearance as there can be guppies of a very different genotype that have a similar appearance. Yellow platinum in the front of the body is usually a strong indication. However a dark blue "bandit marking" where the yellow platinum color of the Schimmelfennig Platinum is normally expressed would be a necessary prerequisite for the Galaxy phenotype for many people.

Medusa Roundtail

Medusa roundtail guppy. Guppy and photo by Karen Koomans

This may be a case of being a Medusa lookalike. Without a firm record of its ancestry it is difficult to say that it is a Medusa.

Breeders Comments

Karen Koomans

"I've bred this strain for about a year and a half. My initial stock was a mixture of longtail and shorttail guppies, the longtail ones looked like:

Shorttail guppies were born exclusively out of females that showed a transparent line under their belly and throat. Another breeder of this type of guppy, Christiane Müsch from Germany, also reports on this typical female feature."

Platinum Medusa

Platinum Medusa. Picture and guppy by ATFG

This is another case where the actual genetics of the guppy would have to be known before this guppy can be definitely classed as a Medusa.

Presumably the guppy combines Medusa genetics with Full Platinum genetics.

European Spadetail Medusa

Yellow Spade Snakeskin. Hans Peter Neuse

Hans-Peter Neuse's Spadetail looks like it is a Medusa. But according to Hans Peter it is not descended from the Japanese Galaxy.

Hans Peter's strain is based on a line created by Diethelm Schröers, but developed much further. Hans Peter says: "Diethelm developed this strain with yellow snake females (Roundtail) and Blond Red males, also Roundtail. In my tanks some of these blond reds are swimming. They are very nice with a golden metallic body. The red in the fins is a little bit orangish but I like them. There are no Japanese crosses into this strain. The blond reds come from Germany (Peter Uhlig) and the yellow females came from Ralf Loch. The shape of the caudal fin and the pattern is near perfection, of this quality I have only a few."

Blue Galaxy

Japanese Blue Galaxy. Photo by Luke Roebuck.

The Blue Galaxy shown above is the classic Japanese Galaxy phenotype, which involves the addition of the Japanese Grass gene to the strain. Its spotted fins are due to the Grass gene. The blue "bandit" marking in the fore part of the body is characteristic of the original Japanese version of the strain, making this the true Galaxy. The bandit marking is probably due to the Schimmelpfennig Platinum gene. It should be yellow metallic. The fact it is blue metallic may be due to yet another gene.

Variations of the basic Galaxy abound, as the result of crossing with other strains. The caudal fin colors range from yellow and black, to olive gray with yellow spots. The Japanese varieties have a wider range of colors and patterns. The Blue Galaxies have been crossed with Japanese Blue Glass guppies, and is sometimes called a Blue Variegated Cobra because it shares many characteristics of the cobra style snakeskin. This version of the strain also yields yellow and white versions. An albino version is also part of this version of the strain.

Genetics

The wildtype Blue Galaxy is a red Galaxy with the Asian Blau mutation in the heterozygous state. Typical of many Japanese fish, it has fairly complex genetics and a knowledge of its genetic make-up is es-

sential to keeping it true to its heritage. See my "Theory and Practice of Guppy Breeding" and my "Guppy Color Manual" for extensive discussions of the blau mutations and their breeding.

Red Galaxy Fantail

ATFG Red Galaxy Fantail

This is the red version of the Galaxy. This particular strain has a fantail.

White Galaxy

White Galaxy by Uwe Bergmann

The White Galaxy is found in Red and Blue Galaxy drops.

Breeders Comments

Luke Roebuck (2003)

"The White Galaxy I believe is a result of the polygenetic inheritance and interactions of the blau (rr) and golden (gg) (bronze in the U.S., tiger in Asia) genes in the new galaxy strains. It is recessive to normal yellow/gold and multicolored galaxy fins.

My version originated from some fish given to me by Edgar Chiasson in Milwaukee 1998. This version is quite unique and probably the best Albino galaxy version in the world today. A green female was used to make the strain in the earliest of out crosses. "

European Magenta Galaxy

Magenta Galaxy. Picture by Junichi Ito

The magenta gene causes the snakeskin pattern to collapse into a metallic finish or a mixed snakeskin / metallic phenotype. The putative genotype of this combination would be:

$X^{La}Y^{Sc\ Ssb\ Sst}$ M/-

Where Sc = Schimmelpfennig Platinum Ssb = snakeskin body, Sst = Snakeskin fins, M = magenta; La = Lace The Magenta gene is autosomal dominant.

Yellow Grass Galaxy

Hiwatari Galaxy Yellow Grass. Picture sent to Philip Shaddock by Eddie Lee

Eddie Lee, a guppy broker in Taiwan, calls this strain the Hiwatari Galaxy Yellow Grass. There is a bandit blue patch in the front of the body, which usually is a marker for a Galaxy.

Genetics

The Grass and Galaxy guppies make excellent and interesting crosses and are much loved in Asia.

Luke Roebuck reports that he uses the Grass and Galaxies as cross compatible strains, both ways.

The putative genotype for this guppy is:

$X^{Gra}\,Y^{Sc\ La\ Sst\ Ssb}$

Where Gra = grass; Sc = Schimmelpfennig Platinum; Sst = snakeskin tail; Ssb = snakeskin body; La = lace

Blue Grass Galaxy

This is an interesting variation that Tsutsui had on his website, named a "Blue Grass Galaxy." It is a cross between a Galaxy and a Blue Grass guppy.

Genetics

Notice that the guppy appears to be divided horizontally. I think he called it a Galaxy because of the tail pattern and because it has the blue bandit marking. However, it's body resembles more of the

Medusa phenotype than a Galaxy. I think this might be a case where a Grass gene has crossed over and is modifying the expression of the snakeskin pattern on the body and possibly the fins.

Blue Grass Galaxy. Photo by Yoshiki Tsutsui

Santa Maria

Santa Maria with bar pattern in peduncle

Without bar pattern. Pictures: Yours Young

The Santa Maria strain is a Galaxy type phenotype with a navy or blue area of color in the front of the body, usually vertical bars in the peduncle and a coarse snakeskin pattern. The large blue patch of blue is considered to be the Santa Maria trademark.

The strain comes in a number of varieties, but the most popular is a grey body with dark navy lines and a red caudal fin. It is often crossed with cobra (snakeskin) guppies and guppies with mosaic caudal fins.

The Santa Maria guppy has rarely, if ever, been imported into North America and is scarce in Europe. Even in Japan it is maintained mostly by collectors and has never been particularly popular.

The Japanese Breeder Fukagawa is the prominent breeder of this strain since the 1990s. He has produced many variations; such has the Hi-Fin Santa Maria Bottom Sword, RREA Redtail and so on.

Genetics

This patch of blue color is very similar to the so-called "bandit markings" found on the Galaxy strain. It probably is related to the Schimmelpfennig Platinum gene. It is also similar to the blue or black patch of ectopic melanophores found in the front of the body of the Moscow that is due to the Viridis gene. The Viridis gene is strictly Y-linked and its presence may be indicative of a common heritage among these guppies. Perhaps the Viridis (metallic green) gene is the original form of the Schim gene.

In any event, I would think this is a variation of the Galaxy genotype,

with perhaps only a single allele different.

According to the late Yoshiki Tsutsui, the Santa Maria belongs to both the Störzbach Metal and Platinum family of guppies. Tsutsui shows the strain as coming out of a Platinum Sword (Guppy Base Book Vol.1, p. 133), probably the Schimmelpfennig Platinum Sword imported from Germany by Tsutsui. So its genetics combine the recessive Störzbach metal and Schimmelpfennig Platinum genes.

Tsutsui shows the genetics as X Y^{Sa} ss. The ss gene is a reference to the autosomal recessive Störzbach metal gene. The Störzbach autosomal recessive genes appear to be at the root of this guppy, with the Santa Maria gene on the Y-chromosome. I would think there is no Santa Maria gene, but rather the Santa Maria is a Galaxy with the Stoerzbach gene.

The strain shows evidence of snakeskin genes as well, though Tsutsui does not mention this.

Albino Red Santa Maria

Yours Young of Taiwan

A peculiarity of this strain is that the blue stripe identifying this strain turns to red when an albino version of this strain is created. It is a good question why the absence of melanin would turn an area blue on a grey guppy to red on an albino guppy. We do know that pigment color cells influence what type of iridophores develop in association with them. However it is simply possible it is red because

pigment is missing and the area is showing blood.

6 Grass

The Japanese Grass guppy has dot pattern fins and a "Nike" swoosh on the body (Figure 1). It comes in a variety of colors.

Figure 1. Classic Blue Grass guppy.

The name comes from the fact the fins look like a field of grass to the Japanese breeders. Creating a fine, even dot pattern is the goal. This must mean that the grass pattern has snakeskin alleles or additional modifier genes that modify the grass pattern from the chainlink pattern of typical snakeskin strains. The reason I suspect the Grass guppy derives from snakeskins is because the dot pattern on the fins is not that biologically different from the snakeskin pattern, which consists of islands of black color cells in a sea of platinum. And the snakeskin body and fin genes are actually separate genes.

See the snakeskin pattern for a discussion of the snakeskin pattern as "islands of melanophores in a sea of platinum." The Guppy Color Manual contains extensive discussions o the biological basis of this pattern.

The guppy shown in Figure 2 is the result of a cross between a Moscow male and X-linked snakeskin shows a similar phenotype to the Grass.

Figure 2. Moscow male X snakeskin female.

The Grass guppy is a great guppy to use for creating strains with dot pattern fins. The Japan Blue guppy is often found with Grass fins. The Moscow also makes a excellent outcross.

The Blue Grass in Figure 1 was crossed with a Midnight Black Moscow to produce a Red Grass Moscow in the F1 (Figure 3).

F1 Midnight Black Moscow X Blue Grass

Notice that the Nike swoosh has been suppressed by the Moscow genes.

Blue Grass

Blue Grass by Philip Shaddock

Shown here is the classic Blue Grass, the most popular color of the Grass guppy. It incorporates the Asian Blau mutation, which converts red color to metallic blue when heterozygous. A drop of Grass guppies includes Red Grass, the base strain. Red Grass does not have the Asian Blau gene. A dull greyish blue guppy is also produced, the homozygous Asian Blau Grass guppy. See the Red Grass entry for a sibling of the male pictured above. There is also a yellow version of the strain and other less common color varieties.

When the background color of the fins is transparent, the guppy is described as being "glass" as in Blue Glass Grass.

Genetics

The Grass gene is sex-linked (*Gra*). It is commonly X-linked.

Although the Red Grass can be maintained separately from the Blue Grass, usually you maintain both types in the same strain, because the Red Grass always appears in a drop of Blue Grass. Simply choose a Blue Grass male and a female with a grass pattern in her fins and you will get both Blue and Red versions of Grass, as well as the homozygous dull colored and virtually patternless version. The homozygous Asian Blau mutants tend to be smaller and somewhat more fragile than their siblings. Knowing the genetics of the Blue

Grass is necessary to maintaining them. The homozygous blau guppy is usually discarded from a drop. Here is what the sibling to the guppy at the top of this entry looked like.

Homozygous Asian Blau version of the Blue Galaxy. Philip Shaddock

Homozygous Asian Blau Blue Grass female.

The putative genotype for the Blue Grass guppy is:

$X^{Gra}Y$ *Ab/ab* *Where Gra = glass, Ab = Asian Blau*

Japanese Galaxy females can be used as a cross-compatible strain.

Red Grass

Red Grass. This is a sibling to the male shown at the top of the Blue Grass entry.

The Red Grass may be considered as a wild type Grass, the base strain for the most popular form of the Grass, the Blue Grass.

Albino Red Grass

Blood Red Grass. Picture courtesy Eddie Lee

Eddie Lee describes this guppy as "Blood Red Grass." The orange-

red color appears to be due to carotenoid red pigment. It also looks like it might have been crossed with a Full Red guppy.

Albino Full Red Grass

Andrew Lim photo.

This Red Grass appears to incorporate the Full Red Albino genes.

Yellow Grass

Larry Hollingsworth's Yellow Grass

This color morph has a great deal of yellow color cells. This guppy appears to have a bandit marking in the front of the body.

Purple Grass

Andrew Lim. Purple Grass

This guppy appears to a mixture of red pigment color and blue iridophores. There appears to be a bandit marking in the front of the body.

Silver Grass

Silver Grass. Guppy and picture by ATFG.

7 Full Golds and Full Platinums

In the *Guppy Color Manual* I discuss guppies described as "platinum" extensively and propose a theory that suggests it is due to two genes, a sex-linked gene (Platinum or Pl) and an autosomal gene (Metallic gold or Mg). The Mg gene cannot be expressed without the cooperation of a sex-linked gene. According to this theory, the sex-linked gene expresses where, when and how much the color gene is expressed. So the Mg gene requires an X- or Y-linked "Platinum" gene. So a Full Platinum is properly genetically identified as:

$X^{Pl}Y$ Mg/-

Since the Pl gene never appears separate from the Mg, this can be shortened to

X^{Pl} Y or XY^{Pl}

since the gene can cross over. The mg gene is implied.

I should add that the body and fins can have separate genetics, so to be correct you should add the Platinum fin gene (Plt) to the genotype:

$X^{Pl\ Plt}$ Y Mg/-

Full Golds appear to have essentially the same genetics. They may involve the addition of other genes.

There is one more ingredient necessary to produce the yellow/gold and white platinum color. The half-black gene (Ni) is required. So the full genetic description of a Platinum guppy is:

$X^{Ni\ Pl}$ Y Mg/- or $X^{Ni\ Pl}$ Y because the mg gene is implied.

The mg gene can have many expressions, depending on its interactions with other color genes, but its most obvious and common expression is that it gives the guppy a white color overlaid by yellow.

The Half-Black Yellow may be regarded as the basis for Full Platinum and Full Gold strains. A Half-Black Yellow is a guppy that does not have the Mg gene for the body, but it does have the gene for the fin colors. This suggests that the body and fins can be under different genetic control.

There is a long standing rule that you cannot create a half-black green guppy by crossing a half-black yellow with a half-black blue. You get a greyish dirty bluish green guppy. This is because the yellow color cells proliferate in the presence of the white color cells. In the layered system of color cells, the repulsion of black color cells from yellow colors that thins out yellow color cells is blocked by the white color cells. The white color cells act as insulation between the black and yellow color cells. Again the *Guppy Color Manual* is the reference here.

Since yellow color cells have motile pigment, the yellow color can fade out under stress. Often you see "White Full Platinum" guppies offered for sale on the Internet. The picture of the guppy makes them look all white. But the buyer receives them and discovers they have yellow color that varies according to the guppy's mood and the lighting.

When the yellow color cells are removed genetically, something curious happens. The guppy becomes a silver color. (See Silverados in the Magenta chapter.) Color cells influence each other. Apparently the

absence of yellow color cells in magenta guppies causes iridophores to develop as silver iridophores rather than white iridophores.

I think of Platinum as a descriptive term rather than a genetic term. It describes the shiny metallic color of a variety of different phenotypes, due to a variety of different genes. Usually it describes metallic colors caused by Y-linked genes. The Schimmelpfennig Platinum Sword also produces a metallic yellow color on the front of the body. It has the mg gene as well, but the gene is expressed differently. It is a different "platinum" gene than the metallic yellow of the Full Golds and Full Platinums.

The White Saddle Gene

There is another type of white color gene. The white saddle gene that colors the dorsal white on Full Platinums may also be responsible for turning the half-black area white.

$X^{Ws}Y$ or XY^{Ws}

Platinum Versus Gold Metal

There are perhaps two types of white color cells, leucophores and iridophores. They may be distinguished as being dull and shiny respectively. A white Micariff looks shinier and more completely white then a white Full Platinum. whose platinum color is unevenly distributed. Leucophores and iridophores are very closely related and usually categorized together. Whether a cell develops as a leucophore or iridophore is due to the specific combination of genes in a strain. I have had Platinum strains that have produced gold metal guppies.

Albino Full Platinum

Albino Full Platinum. Guppy and photo by Philip Shaddock.

This phenotype is popularly described as a Full Platinum.

The guppy is a combination of white leucophores (seen in the front of the body and the fins of the pictured guppy) and a yellow platinum color. The Albino is the most commonly found variation because the albino gene genetically removes black from the guppy and the yellow and white colors increase in density when black color cells are missing.

Genetics

The base strain for this guppy is the half-black yellow.

The genotype of the Albino Full Platinum is:

$X^{Ni\ Ws\ Pl\ Plt}\ Y^{Ni\ Ws}$ aa mgmg

Mg = Metallic Gold, Ni = half-black , Ws = White Saddle, a = albino, Pl = Platinum body, Plt= Platinum fins

As you can see I have coded the Ni and Ws genes as homozygous. This is because I have found in most strains the male and female each carry a copy of the constituent genes. Apparently making the genes homozygous intensifies the platinum color.

The American Half-Black Yellow has the same genetics on the fins as the Full Platinum has on both the fins and the body.

Female Full Platinum. Notice the metallic gold color on her body, a sure sign that she has Platinum genetics.

Albino Full Platinum Picture courtesy of ATFG. This guppy is not showing yellow in the picture.

Gray Full Platinum

The grey version of the Full Gold Leucophore is similar to the albino version. The white platinum color appears to be more prominent, and

the metallic gold less prominent. This may have something to do

Grey version of the Full Gold Leucophore. Notice the female in the back.

Full Platinum Redtail

Full Platinum Redtail. Picture by Vladimir Storozhev. Used with permission.

This guppy has a yellow platinum body and red fins. It has some red in the peduncle area as well.

It goes by various names in the hobby, such as the Sunset guppy. However it is simply a Full Platinum that has been crossed with a guppy with red fins. As noted in the introductory notes, there is a

Platinum gene for the body and a separate gene for the fins. This appears to be the case where the red fin genes are somewhat epistatic to the fin Platinum gene. The red in the peduncle area suggests that the original cross may be to a full red.

Albino Blue Platinum

Guppy photo by Luke Roebuck.

This strain has a shiny, white and gold metallic appearance with a blue cast. It's pink eyes are due to the albino gene.

Genetics

This may be a Full Platinum with the blau gene. See Luke Roebuck's description below. The blau gene would convert red color cells to blue metal color, giving it is overall bluish color.

Breeders Comments

Luke Roebuck

It is known as Platinum but with a new twist- Blue (blau) Platinum. It is the result of a cross between the golden Platinum and the Japan blau "cheat". The colors are chameleon like platinum gold in the body and blue-gold in the tail. When settled down it looks sky blue in the fins! These are the young F1 siblings from the WGC auction in Czech Republic.

Albino Full Gold Blau

This albino guppy has a shiny gold metallic body and blue fins.

This particular strain segregated out of a cross I conducted between an Albino Blau and a Glass Belly Panda.

Full Gold Albino Blau. Picture and guppy by Philip Shaddock

The putative genetics of this strain is:

aa Abab mgmg

Where mg = metallic gold, a = albino; Ab = Asian Blau

8 Schimmelpfennig Platinums

I have put the Schimmelpfennig Platinum mutation into its own category to help distinguish it from the Full Platinums and Full Golds due to the Platinum gene and its autosomal co-factor the Metallic gold (Mg) gene.

While I believe both forms share a common autosomal gene, the Mg gene, the Schimmelpfenning Platinum sex-linked gene (Sc) expresses the yellow platinum color primarily in the front of the body and in the caudal fin, whereas the Full Platinum body gene (Pl) gene is expressed primarily in the peduncle area. I actually combined the two genes to create a strain I called "Double Yellow" with an overall body platinum yellow color. (See below).

The *Guppy Color Manual* is the reference for the theory about the relationship between sex-linked and autosomal color genes.

As you will see in this chapter, the Schimmelpfennig Platinum gene is used in a number of crosses to create unique guppy designs, not

least of all the famous Galaxy and Medusa guppies out of Japan. If you are interested in playing with guppy genetics, this would be an excellent strain to have in your fish room.

Schimmelpfennig Platinum Sword

Photo by Philip Shaddock

The blond version of the same strain.

Schimmelpfennig Metal is the original German name for this strain, sometimes called Schimmelpfennig Sword. Platinum Sword

is another less accurate name. It is also called the Schimmelpfennig Platinum Lyretail because of the poor sword shape.

The Schimmelpfennig Sword was discovered and developed by Horst Schimmelpfennig, a guppy breeder in Berlin. It is a mutation out of the Viennese Emerald Green Swordtail strain. (According to an account told on the Guppy Club Singapore forum by a German breeder, the strain originated from the Coral Red strain.) This strain is in turn is the foundation for many popular metallic strains found in Europe and Japan. The Japanese developed many of their "platinum" strains from imported Schimmelpfennig Platinum Swords. The Galaxy guppy is descended from a cross between this strain and a lace snakeskin.

Description

The Schimmelpfennig Sword is usually a bright, shiny yellow in the front of the body. The platinum yellow color is not homogeneous across the body. However, the swords do appear to have yellow platinum color.

Notice that the half-body area in the blond version of the strain is completely lacking the platinum yellow color. And the dorsal is yellow instead of white.

The blue metallic color you see in the above picture is probably due to the Emerald Green Iridescent (EGI) gene. It appears to be the background color for the entire body. The strain is said to be very difficult to maintain to show quality standards. The double swords tend to develop into ragged lyre tail shapes. The swords are also said to be too narrow, tending toward parallel growth. They can have different lengths, and a new fin extension can develop.

However in the strain I acquired from a Hawaiian breeder, the swords were actually quite good.

Genetics

As I noted in the previous chapter, the genetic makeup of the platinums include a sex-linked gene (Sc in this case) and an autosomal gene (Metallic gold or Mg). Commonly the Schimmelpfennig Platinum gene (Sc) is found Y-linked. But it can cross over.

The genetics for this strain is:

XY^{Sc} Mg/-

I usually omit the Mg gene symbol as it is implied by the phenotype.

As a Y-linked metal gene, the Schimmelpfennig Sword may have been described much earlier than that found by Schimmelpfennig. It is possible that the first "platinum" guppy was actually described by Winge in 1927 in his THE LOCATION OF EIGHTEEN GENES IN LEBISTES RETICULATUS (*Journal of Genetics*, 18,1, page 21) paper. He describes the Cinnamomeus Y-linked strain as "a peculiar metallic sheen, of a warm brownish yellow, on the side of the body; most conspicuous in direct light."

The Schimmelpfennig Sword crosses well with the Viennese Emerald Green because of the close kinship between them. Crossing with Coral Red DS females produces a version with deep yellow colors.

In one of the crosses that I have done with this strain, a sport appeared in a drop (see below). This was a crossover guppy that has lost the Schimmelpfennig Platinum gene. This shows that the base strain for the Schimmelpfennig is the Viennese Emerald Green strain.

See the Emerald Green Iridescent color at the base of the peduncle? This is what a Schimmelpfennig Platinum Sword looks like when it is missing its metal gene. Notice the overall blue metallic color of the body.

Sport appearing as a result of a crossover.

The blond version shown above shows more clearly than the grey version that the yellow platinum color is somehow genetically prohibited from coloring the peduncle.

I have combined this strain with the Full Platinum (which colors the half-body area) to produce the Double Yellow guppy.

Double Yellow

Double Yellow. Guppy design and photo by Philip Shaddock

At first glance this looks like a Full Platinum. In fact it combines two "platinum" strains, the Y-linked Schimmelpfennig Platinum Sword and the Full Platinum. The Schimmelpfennig Platinum gene (Sc) colors the front of the body and the Full Platinum (Pl) gene colors the peduncle. That is why I call it a "double yellow."

The genotype is:

$X^{Pl}\ Y^{Sc}$

Where Pl= Platinum, Sc = Schimmelpfenning Platinum

The guppy in the photo is young. Eventually the caudal fin developed into double swords and the guppy became more yellow.

El Dorado

El Dorado bred by Luke Roebuck

History

According Iwasaki in Aqua Life magazine, in 1990 Hiroshi Sugino crossed a German Schimmelpfennig Platinum Sword and an Old Fashion guppy (see the Color Strains entry for this strain, which is based on the German Emerald Green sword). Some of the F1 showed a triangle delta tail. Then Gen Hideshima used the F1 to cross to Japanese Mosaic. This is how the original El Dorado was born. The name El Dorado is said to be given to the strain by Japanese breeders, who took the name from the ancient "Lost City of Gold" known as "El Dorado."

Description

The El Dorado has the yellow platinum color of the Schimmelpfennig Platinum gene in the front of the body. It also has greenish metallic color which may be due to the German Emerald Green sword (EGI gene).

Apparently the original El Dorado strain had a platinum yellow body without the green and blue. This suggests that the greenish color may be due to the Stoerzbach gene instead of the EGI gene. It had a yellow-orange to red tail including a black dot in the caudal fin. They

were small with a narrow caudal fin spread (veiltail). The fin shape was doubtlessly due to double sword genes from the Emerald Green swords.

Albino El Dorado

Albino version of the El Dorado. Luke Roebuck. The albino version seems to have lost its greenish metallic color. Is it a version without the Stoerzbach gene?

Genetics

This strain incorporates the Schimmelpfennig Platinum gene, not the Full Platinum (Pl) gene. A later addition was the Stoerzbach gene. This is made somewhat doubtful by the fact that Luke's image of the albino version of the strain shows no greenish metal color. Is this version one without the Stoerzbach gene?

A Japanese Old Fashioned guppy is created by crossing a Vienna Emerald Green Doublesword to another strain, producing a variety of phenotypes depending on the outcross strain used. So it is difficult to reproduce this strain without knowing what the original outcross strain was. The subsequent cross to the Schimmelpfennig Platinum Sword was likely to a male, since the Schimmelpfennig Platinum

gene is usually Y-linked. The fact that the guppy has red fins suggests that the original outcross strain had red fins.

The account of the El Dorado's origins by Iwasaki is interesting. In crossing the original Old Fashioned guppy to the Schimmelpfennig Platinum Sword, the breeder is in effect re-inforcing the Vienna Emerald Green genes in the Old Fashioned guppy. That's because the Vienna Emerald Green sword is the base strain for the Schimmelpfennig Platinum Sword.

Yoshiki Tsutsui's family genealogy of metal guppies shows the El Dorado descended from a Schimmelpfennig Platinum Sword that landed in Japan in 1990. It belongs to a group that includes the Santa Maria and Galaxy.

A comparison between the El Dorado and the Schimmelpfennig Sword shows their similarity.

As you can see in the above photo, there is a lot of green metallic sheen in this guppy. This is due in part to the EGI (Emerald Green Iridescent) gene that is part of the Vienna Emerald Green strain makeup. Still, there is definitely an overall greenish metallic cast on

the El Dorado, so it is still possible it has the Stoerzbach metal gene. The putative genetics would be.

El Dorado: $X^{Rdt}Y^{Sc\ Smlr}$ ss

Where Sc = Schimmelpfennig platinum; Smlr = Emerald Green Iridescent; s = Stoerzbach metal; Rdt = Red fins

Red Fin Metal Speartail

Red Fin Speartail. Photo by Finn Bindeballe

This strain appears to have platinum gold color in the front of the body and coral red in the half-body area, plus a red tail.

Genetics

Most likely the platinum yellow color comes from the Schimmelpfennig Platinum gene.

Blond Platinum Speartail

This is a very old strain. The original developer is unknown. However the Schimmelpfennig Metal Sword was a mutation out of the Vienna Emerald Green Swordtail, and since this strain looks like the Schimmelpfennig Metal strain, that is a likely origin.

The picture shows a blond version of the speartail.

Platinum Speartail. Picture by Flemming Stræde

Breeders Comments

Flemming Stræde

Guppy and Picture by Flemming Stræde

"I got it from Matthias Manken in Germany a couple of years ago. It is a very old strain, living proof that inbreeding isn't a problem in guppy breeding.

From the start we had some troubles, with males being infertile due to extended gonopodiums. That problem we succeeded breeding out of the strain. To be honest females are an ugly looking guppy, but it seems to have no effect on the males.

The strain is pure breeding, but it doesn't produce a lot of fry, twenty fry per batch is normal. Heavy feeding with live food, or any kind of high protein food will bring up numbers.

The strain has in the past year done very well in European shows, and several times it has reached points in the eighties. As far as I know, only three European breeders keep the strain, so its not that common.

I have only taken a few good pictures of this strain, and to be honest not two with the fish showing the same color. It sort of changes with the background, plants or what kind of mood it's in. It's not a problem though. Seems like all fish in a tank pick up on the same colors, like a common chameleon characteristic."

Platinum Red Mosaic

Platinum Shocker. Photo and guppy by Junichi Ito.

According to Junichi Ito, this strain originates out of Thailand. He calls it a "platinum shocker."

The guppy has a mosaic pattern in a fan-shaped tail. It has a strong yellow platinum color in the front of the body. There are bars in the peduncle. It is commonly called a "Red Galaxy" but the fact it does not have a "bandit marking" and the prominence of the platinum color in the front of the body indicates that it may not be a true Tsutsui Galaxy.

Genetics

The yellow platinum color in the front of the body is due to the Schimmelpfenning gene. The snakeskin features on the body are due to the snakeskin gene. The red mosaic color in the fins are due to the Mosaic fin gene. So what do you call this combination of genes? I would call it a Galaxy "type" meaning it lacks the bandit markings of a true Tsutsui Galaxy. It is probably a very similar cross, but may not involve the lace gene. The big difference is the inclusion of the fantail and Mosaic genes. So I would suggest the most accurate name is Platinum Red Mosaic.

So the putative genotype of this strain is:

$X^{Mo\ Fa}\ Y^{Sc\ \ Ssb}$

Where Sc = Schimmelpfennig platinum, Mo = Mosaic fin gene, Ssb = Snakeskin body, Fa = fantail

9 Pink Whites

Pink Whites are characterized as having white fins and a white area at the top of the peduncle near the juncture with the caudal fin.

Pink Whites are not the same mutation as the Pink mutation, despite the fact both genes can be expressed with white color. The Pink mutation affects the full body whereas the Pink White appears to affect only the caudal fin and the top rear of the peduncle. The Pink White involves a sex-linked gene (Pw) and an unknown autosomal gene, while the Pink mutation involves an autosomal gene whose effect on the phenotype is known in Pingus and Pandas.

Pink White Half-Black Yellow

Pink White. Guppy and photo by Philip Shaddock

To develop a better understanding of the expression Pink White gene, I crossed a male Pink White Moscow with a Half-Black Yellow female.

The result of the cross was a white finned guppy resembling a half-black white. There was some black streaking in the caudal fin, as you can see in this picture. Both males and females showed the typical Pink White area at the upper dorsal side of the peduncle at the base of the caudal fin.

Genetics

I had done outcrosses with the Half-Black Yellow strain before and found that the phenotype is largely determined by X-linked genes. So it was no surprise that the F1 resembled the Half-Black Yellow mother strain. However, it was interesting that the normally dominant yellow color is not expressed. Obviously the Pink White gene influences the color of the fins.

The genotype of this guppy is: $X^{Pw\ Yt}Y^{Ni}$

Where Pw = Pink White; Yt = Yellow Tail; Ni = Half-black

I believe the white in Pink White is due to leucophores. It looks like black color cells are expressed as leucophores when the Pink White allele is present, as in the white area of the cross I did.

Snow White

Snow White. Guppy and photo by Tomoko Young.

The Snow White has a deep white color with some greenish highlights. It has a deep white patch at the base of the peduncle and white fins.

Genetics

Tomoko Young has said Snow Whites are a development of Pink Whites. It is possible the strain is a combination of Pink Whites and a strain with the Metallic gold (Mg) gene. However, the presence of greenish highlights suggest it may also have the Stoerzbach mutation.

The putative genetics for this strain may be:

$X^{Pl\ Pw}Y$ ss

Where Full Platinum; Pw = Pink White; s = Stoerzbach

Green Platinum Pink White

Platinum Green Pink. Used with permission from Uthen Chaichot.

This guppy shows its Pink White heritage in the white base of its peduncle and in a small white area at the base of the caudal fin. However the dominant phenotype is a green platinum body. If you look closely at the base of the female's peduncle, you will see a "pink white" area. The red caudal fin indicates a red tail gene is part of this strain's genetic makeup.

Genetics

I crossed females of this strain with Hawaiian Blue Moscows males and got Blue Moscows with light blue fins and the pink white patch in the peduncle. (See the *Pink White Moscow* entry.) This was in the F1 generation. The females showed white at the base of their peduncle as well. Since the females were composed of one X-linked allele from the Moscow father and one X-linked allele from the Pink White mother, the conclusion must be that the Pink White allele is dominant. The fact that the males or females did not have red in their fins, indicates that this strain had a Y-linked red tail allele (*Rdt*).

Albino Japanese Pink White Swallow

Albino Japanese Pink White Swallow. Photo by ATFG.

This guppy shows the combination of the Pink White gene (seen at the top of the peduncle) with the albino and swallow genes. There appears to be yellow spots in the body as well.

10 Pinks and Pingus

Both Pingus and Pinks share the same gene, the autosomal pink (pk) gene. The difference is that the Pingus have the half-black gene (Ni) as well as the Pink gene. Females typically have a heavy reticulation pattern.

This mutation is not related to the Pink White mutation.

The gene is said to be epistatic to red color cells.

Pingu

Picture and guppy by Luke Roebuck. According to Luke, David Liebman said his strain was closest to the original Pingus. You can see the resemblance between this strain and the picture in the ad below.

The name "Pingu" is a contraction of "**Pin**k **Gu**ppy," given by the original developer of the mutation, David Liebman. The Pingu guppy

has what appears to be white color cells in place of black color cells in the half-body area. However the name is somewhat of a misnomer as the Pink gene is epistatic to red color cells when it is homozygous. The pink color must come from blood in the skin.

The original mutation that gives this strain its name was developed by the David Liebman over ten years. We can see what the original Pingu looked like in the ad he placed in "Tropical Fish Hobbyist," December, 1979. Notice the similarity to Luke's Pingu at the top of this entry.

A clue to the origins of the Pingu is where it developed on the guppy's body. In his article, David Liebman shows in a picture of the original mutation. Notice the pink spot in the upper part of the peduncle.

Pink spot on peduncle of early Pingu.

The original Pingu appears to be a half-black guppy, and the Pingu pattern appears to have begun with matching pink spots on both sides of the peduncle. Liebman was to selectively breed the pattern until it covered the peduncle area:

The genotype of the pingu is: XY^{Ni} pkpk.

Pingu Panda

Pingu Panda. Picture courtesy Dirk Czajkowski

The strain has the Moscow Blue background, white areas due to the homozygous pink genes and a pink half-body area due to the half-black gene interacting with the pink mutation. It's genotype is:

$X^{Ni}Y^{Mw}$ pkpk

Where Ni = half-black, Mw = Moscow, pk = pink

Platinum Pingu

Platinum Pingu. Philip Shaddock

Platinum Pingu female. As she got older she developed a completely metallic peduncle like her brother above.

The Platinum Pingu has a heavy reticulation pattern on the upper part of the body. The peduncle is dominated by a pinkish white Pingu pattern. Over top of this pattern is laid a bluish metallic coating. Both males and females exhibit the traits. There is yellow in the caudal fin, the dorsal and the front of the body from the Full Platinum gene and its cofactor, the Mg (Metallic gold) gene.

Genetics

The pictured specimens segregated out of a cross between a male Pink White Half-Black Yellow male and a blond Glass Belly Panda female. The Platinum gene came from the Panda female, so it is X-linked. The Platinum gene's expression is modified from a burnished gold color (seen in the front of the body) to a bluish white sheen seen in the peduncle area. This color differentiation may be due to the presence of the half-black gene.

The putative genetics of this strain is:

$X^{Pl}Y^{Ni}$ pkpk *Where Pl = Full Platinum, Ni = half-black, pk = pink*

Panda Moscow (Pink Moscow)

Photo by Finn Bindeballe

Pink Moscow is the name given to this phenotype in Europe.

Yoshiki Tsutsui documented the Pink X Moscow cross. He named his creation the "Panda Moscow."

The Panda Moscow shows the competing influences of the Pink guppy and Blue Moscow guppy, resulting in a mixture of white and blue areas of color. The black eyes and the white front of the body are markings that give this guppy its name, resembling the Panda bear. Generally Moscow Pandas tend to be smaller than either strain they descend from. They have round short tails, although delta tails have been reported by some. European variations of this strain may have snakeskin markings on the peduncle.

Genetics

The strain is the result of crossing a male Moscow (Y-linked) with a female Pink (autosomal recessive).

XY^{Mw} pkpk

Where Mw = Y-linked Moscow, pk = autosomal recessive pink

Glass Belly Panda

Picture by Philip Shaddock

This is a small strain. It has a short round caudal fin. Besides the typical Panda markings, the most obvious characteristic is the transparent belly. You can see the eggs and the eyes of the developing fry in the

female's gravid spot area in the above photo. Also notice the lack of iridophores (reflecting cells). The eye is all black with no silver iridophores. There appears to be some iridophores in the front of the body, but the body generally lacks iridophores, a characteristic of the glass belly mutation.

Notice also the blood showing in the gills. Normally this is an area covered by shiny iridophores, protecting it from the sun. The peachy color of the female is typical of this strain. The fry are born with this color.

Genetics

The strain is a combination of Panda and the Glass Belly alleles. The Glass Belly allele is autosomal recessive. So the gene notation for this strain is:

XY^{Mw} gbgb pkpk *Where Mw = Moscow, gb = Glass Belly, pk = Pink*

The glass belly gene seems to affect only *silver* iridophores, the type found in the belly and in the head and eyes. That is why you see some shiny metallic blue color in the body and the fins.

The other notable feature of this strain is that the dull black color on the male does not appear to fade, unlike the black usually found on Moscows. This suggests that the glass belly mutation may affect melanophores as well. But this is not certain.

Blond Glass Belly Panda

Blond Glass Belly Panda

A blond version of the strain was part of the original strain I ac-

quired. It has the putative genotype of:

XY^{Mw} gbgb pkpk bb

Where Mw = Moscow, gb = Glass Belly, k = Pink or Pingu.

11 Blue Metal Guppies

This group includes the guppies showing a high concentration of blue iridophores.

Blue Diamond (Luster)

Junichi Ito supplied us with this photo of a Luster guppy. It is likely to be the same as the Blue Diamond guppy.

The Japanese Luster strain may be the same as the Asian Blue Diamond strain. The gene covers the body with a light, metallic blue. You can certainly see this effect in the above picture.

Genetics

Most of the blue on guppies is due to blue light reflecting cells called iridophores. So the metallic blue you see on the guppy above is the result of the proliferation of an arrangement of these iridophores. The gene Blue Diamond (Bd) is said to be Y-linked. Presumably it crosses over.

Full Metal Ivory Blue Mosaic Full Moon

Ivory Blue Full Moon. Guppy and photo by ATFG

This may be the same basic strain as the Blue Diamond. It appears to be a half-black guppy with a metal gene. The tail has the "full moon" shape.

Lazuli

This guppy was designed by Satoshi Kobayashi from the Osaka Kansai Guppy Club. Picture used with permission.

European Lazuli. Photo by Björn Lundmark.

The Lazuli originated with Taketoshi Sue who works in Hiratsuka Bio Giken. The year it first appeared was 1999. The Lazuli Mosaic appeared in 2000. The Lazuli generated a tremendous amount of interest in the Japanese guppy press.

The Lazuli gets its name from its color, the aquamarine blue of the Lapis Lazuli gem.

The Lazuli has long been described as a Japan Blue with extra genes for the color, particularly on the head. (A common name for the Japan Blue in Asia is Aquamarine.) This potentially makes the Lazuli as exciting a development in the guppy world as the Moscow, which also has a blue head. It joins a unique category, one that also includes the Singapore Neon Blue, the Full Red, and other strains. The German breeder Robert Gall believes that the Lazuli is actually more related to Coral Red guppy (part of the Vienna Emerald Green family). See below.

Genetics

According to the late Yoshiki Tsutsui, the Lazuli has an additional color gene on its Y-chromosome for the blue head. The body is a different Y-linked blue gene. So it is similar to the Moscow in its genetics. The origin of the blue head gene is unclear. It might even be Moscow since the x-linked Japan Blue exists. But that is doubtful because the Lazuli was around before the x-linked Japan Blue.

Breeders Comments

Robert Gall

"The following comments reflect my experiences with lazuli and coral red, both of which I have bred.

The body color lazuli is only found to be Y-linked. This color appears as a bright blue on the fore body. This bright blue differs clearly from Japan Blue.

There are some striking similarities between lazuli and coral red. The intensity and the development of the lazuli is similar to coral red. In the fish room of Gernot Kaden, Pirna, Germany, several red males appeared among lazuli offspring of various lazuli delta and double sword types. These red "lazuli" were very similar to the different shades of red of coral red. Coral red combined with the Asian Blau effect appears bright blue, very similar to lazuli. So there are similarities.

Lazuli males seem to have, like coral red males, no trait for a dorsal coloration on the Y-chromosome. They do have double sword traits but these traits are not that good and equal to the traits of coral red (which differ from the DS traits of platinum strains or Vienna Emerald strains). Especially the spreading of the swords is rather bad.

When lazuli is combined with other body colors or patterns, it behaves in some cases similar to coral red. A combination of lazuli and X-linked snake skin leads to a combined pattern of lazuli and snake skin. It is very similar to a pattern of coral red and snake skin. The lazuli is reduced to a blue bar close behind the operculum. The rest of the body is covered by the snake skin pattern. A similar combined pattern can be observed on a guppy with the coral red and snake skin genes.

In contrast to coral red, lazuli is just a single trait: a bright blue coloration of the fore body. The coral red body color is a combination of at least two traits: a metallic red fore body and a poor light blue on the lower part of the peduncle. This light blue can also appear on males of other strains and is probably a recessive Y-linked trait of the Vienna Emerald trait-complex. Under special circumstances Vienna Emerald also show this trait on the peduncle. There is a doublesword strain which permanently shows this trait. It was a mutation in my Vienna Emerald strain and is now bred by Gernot Kaden. The dorsal coloration is lost, too. It shows that there is a relationship between the traits for the dorsal color and body color of certain strains.

An interesting observation is that Gernot Kaden's red "lazuli" also

showed this poor light blue on the peduncle, which makes them appear even more like coral reds. The normal lazulis don't seem to show it.

Lazuli seems to be a similar gene/trait as the gene/trait for the metallic red color of the body color coral red. Whether the lazuli trait is just a variation of the gene for metallic red color of the coral red or is a similar but independent gene, can not be said yet."

See the *Turquoise* strain, which appears to be a closely related mutation.

Lace Snake Lazuli

Photo by Björn Lundmark.

Description

Björn Lundmark told me that this was a cross between a Lazuli and a Galaxy. It is interesting because the Lazuli looks like it has a lace snakeskin body. Since the Galaxy genotype includes the lace gene, this is obviously what is expressed here.

Turquoise

The turquoise gene produces a metallic turquoise (blue green) color on the body and base of the caudal fin.

The mutation was discovered in a drop of Red Mosaic guppies in the spring of 2003 by the Japanese breeder Masanori Suzuki, associated with the "Delta Space" guppy speciality store, owned by Mr. Ino-

mata. It has since been extracted from the strain and applied to other strains, such as this "Green Tail," a solid color guppy with a turquoise body.

Junichi Ito has said that it is similar to the Lazuli, although the Lazuli is blue purple in color rather than blue green.

Original Turquoise guppy. Photo supplied by Junichi Ito.

It is interesting to note that it is said to come out of a red guppy, paralleling what Robert Gall has said about the origins of the Lazuli.

Green Tail. Picture courtesy Junichi Ito. You can see the IFGA Green influence in this guppy's body

and fin proportions.

Genetics

Junichi says the gene is Y-linked, although it is expected to become X-linked as well, just like the Lazuli.

Japan Blue (Aquamarine)

The Classic Japanese Japan Blue. Guppy and photo, Philip Shaddock

The Japan Blue is known as the Aquamarine in Asia. It has a bright, metallic sky blue body and fins that can be solid, dotted, mosaic, red or a variety of other colors. It is the purity and sky blue quality to the iridophores on the half-body area that gives this strain its special quality. The spotted fins seen in the picture above probably resulted from a cross with the Japanese Grass guppy.

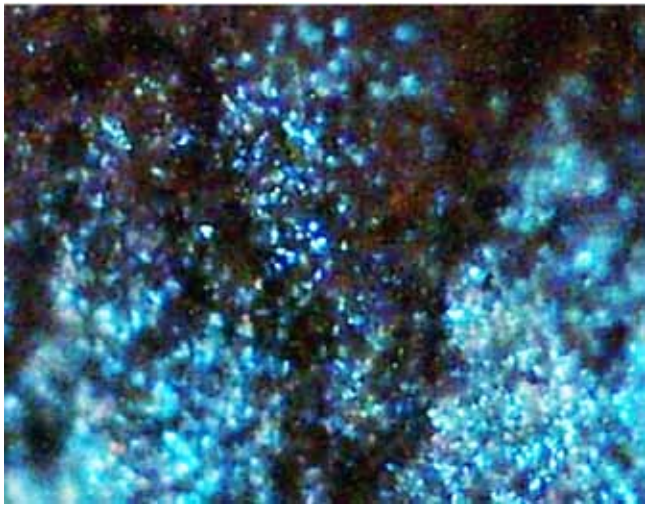
The Japan Blue comes originally from the wild. The wild form was discovered in a river in the Kanagawa Prefecture around the late 80's. The wild type does not have the large flowing tail of the contemporary version, but it is beautiful in its own right. The Japan Blue was first described in a Japanese fish magazine in 1994.

As soon as the wild Japan Blue was discovered, the Japanese began to put its gene in their fish. Yoshiki Tsutsui developed the Topaz (RRE Albino Japan Blue Neon Tuxedo) strain from the Japan Blue.

It is the metallic blue of the Japan Blue that makes it unique.

- First of all it is the heavy density of blue reflective cells, the iridophores in the half-body area. These provide the guppy with its well-known metallic look.

- The second trait may be related to the first. The Japan Blue seems to have exclusively blue reflective color cells (iridophores), and no white, silver, or iridescent iridophores, at least in the half-body anterior part of the body.

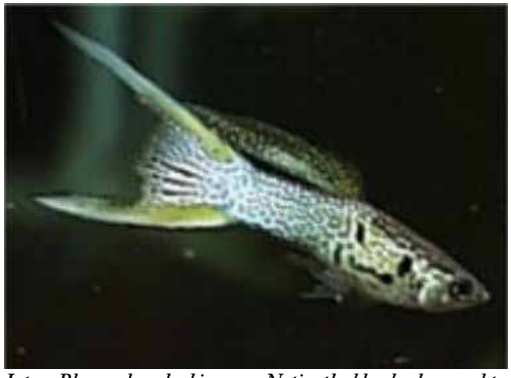


Microscope view 100x of the blue peduncle of the Japan Blue.

The Japan Blue gene has the gene symbol "A" for Aquamarine.

This guppy is fun to cross because of its interesting genetics. A cross-over has created an X-linked version, but the most common location of the Japan Blue gene is the Y-chromosome. It is fairly tightly linked to the sex-determining region on the Y-chromosome.

Genetics



Japan Blue and snakeskin cross. Notice the blue background to the snakeskin

pattern.

Häkan Turesson reported that a cross between a Y-linked Japan Blue and an X-linked snakeskin produces offspring showing both traits. When the fry are young they show a lot of Japan Blue color, but as they get older the Japan Blue is overtaken by the Snakeskin pattern and shows only a tint of blue under the snakeskin pattern. The cross between an X-linked Japan Blue female and male Galaxy produces a beautiful combination. An interesting cross is the Japan Blue male to a half-black female. The half-black appears metallic.

Albino Japan Blue

Albino Japan Blue

Wild Japan Blue

A wild type guppy with Japan Blue. Photo by Karen Koomans

The albino version of the Japan Blue loses much of the intensity and saturation of its blue color. The reason is that black color cells (melanophores) at the base layer of the skin act to absorb light passing through the skin. When it is absent, as in the case of the albino Japan Blue, the light is reflected back through the skin, washing out the blue to some extent.

The guppy at the top of this entry is a classic Japanese version of the "Aquamarine" guppy. It is probably the result of a cross between a wild Japan blue and a Grass guppy. The dotted pattern in the fin would suggest this. Since the Japan Blue metallic color only affects the peduncle, the genetics of any particular form of Japan Blue will depend on the presence of the gene for the fins. For example, a Japan Blue with red fins is popular. In the wild form the fins were colorless and short, or with some color. So the genotype for the guppy at the top of this listing is:

$X^{Gra}\,Y^{A}$

Where Gra = grass fins, A = Aquamarine or Japan Blue

Blue Metal Doublesword

Yellow Fin Blue Metal Doublesword

At first glance this guppy appears to have the Japan Blue gene. However, the fact that the blue / green iridescent color spreads over the entire body makes this somewhat doubtful. This is more indicative of the action of the Emerald Green Iridescent (EGI) gene. Or perhaps it is a combination of both Japan Blue and EGI genes, co-dominantly expressed.

12 Stoerzbach

Guppies in this category have a heavy proliferation of blue iridophores, that appear to cover the entire body. It is due to the Stoerzbach gene, an autosomal recessive mutation.

Stoerzbach Metal Swordtail

Male and female Stoerzbach Metal Sword. Philip Shaddock

This is the classic Stoerzbach Metal Sword, with a metallic blue body and yellow fins. The reddish color in the upper and lower swords is also typical. The female is colorless, although there appears to be a little yellow color at the base of the tail fin.

Genetics

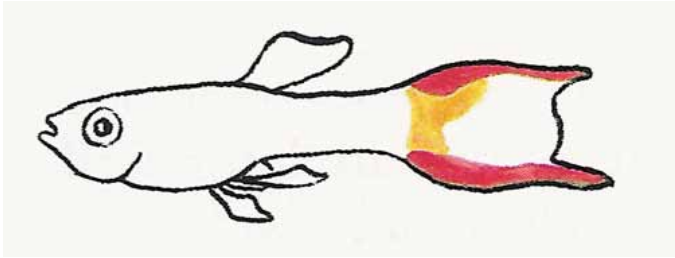
The guppy shown above mutatated out of a Vienna Emerald Green strain.

Gene symbol:

ss

Where s= Stoerzbach Metal

The reddish color in the upper and lower swords is said to be the Elongatus gene (*el*) originally described by Winge. Kirpichnikov shows this picture of the strain:



In his 1927 paper, Winge describes this guppy as:

> A gene, *elongatus (el)*, involving elongation and coloring of the caudal fin in Lebistes males, was found (loc. cit. 1923 a) to be inherited in the typically sex-linked manner; the gene must therefore have been situated in the X chromosome. (p. 2)

This appears to be an early form of the double-sword. Notice that the shape of the fin is associated with color.

So the genotype for the German Stoerzbach Metal strain should be:

XY^{el} ss

I am assuming the Elongatus gene is Y-linked because the strain is regularly outcrossed to neutral females.

Breeders Comments

Erwin van Virdum

On wild type grey the Stoerzbach color looks blue/green. There are lots of yellow color cells present and the dorsal and caudal fin are yellow. On the blond the fish look yellow/gold. The Viennese Emerald pattern is present underneath the Stoerzbach, when fish are stressed this pattern can be recognised by some red spots visible.

The black spot on the front of the body can be present on top of the Stoerzbach, but I removed it by selective breeding. In my case, the Schimmelpfennig Platinum gene seemed to be present also. The Elongatus genes can be seen in the color pattern on the fin.

When the fish are developing, lower and upper swords develop differently. Maybe this is due to the elongatus genes, don't know for sure. In place of the upper sword, first the yellow/olive drab spot (elongatus) is visible and the lower sword starts to develop. Later there is a small top sword visible. For this differentiation in growth, I can think of two reasons. First is that the elongatus gene adds red color to the top sword and just needs more time to develop red color, or second that part of the color is due to other (X-bound) yellow color genes. Most of the color of the caudal and all of the color of the dorsal fin is due to Y-linked genes, but my females started to develop yellow at the top of their caudal fin.

My latest generations (stopped breeding them a few month ago because I had to move) had well developed lower swords, but the upper swords were getting too small. I strictly selected on the right males (fully colored fins and good shape), so I think the problem was X-linked (maybe yellow color crossed over to the females, so I had to select these females that showed some yellow?)

The females can be used to outcross with different strains. They inherit good fin shape but no color on the dorsal fin. It is a strain that matures slowly but can live up to 2,5-3 years, patience is needed. Because of the differentiation in sword growth and the slow speed of maturation, many of my young fish ended up in a culled fish tank. But after many months some of them looked really good and were put back in the breeding program.

There was something about the shape of the dorsal fin. The shape was very good, starting steep and ending in a point, but the total length was limited. The females had played a part in this, when used in other strains they did improve fin shape (made shapes better in general, but could not solve triangle like dorsals). After using other females (Japan Blue doublesword females) with the Stoerzbach males, the length of the dorsal fin improved. This was clearly an X-linked issue, but it can be said that the Stoerzbach fish developed slower then the non-Stoerzbach.fish.

With the new females the length of the fin was better, but they needed a lot of time to develop to mature in length in comparison with the Viennese Emerald siblings. At first the swords tended to grow crooked or bent, but by selection this issue was resolved. Also by selection the Stoerzbach covered more body area, only a small strip of the back was not colored. The fish also developed colored scales on the head, something that is now included in my Japan Blue strain (now looks blue instead of yellow). Between the swords, the

Stoerzbach filled up some extra tissue, with good selection this was also solved. Although the males looked very good, the females weren't the most good looking. I used them to start new strains with males that I bought at shows... and with success. I don't often see these nice dorsal fins at shows. I remember I had a lot of inbreeding depression, there were not many people who bred these fish so I couldn't add new genes. I kept several lines for several years. I only kept the lines that didn't show too many problems and this is how I could keep the strain.

In one of my previous posts, I attached a picture of one of the show quality males I have bred.

Erwin van Virdum. Show quality Stoerzbach Doublesword

I never myself showed one of these Stoerzbach fish at shows, but Viennese Emerald siblings and the Japan Blue strain made with the Stoerzbach females won first prizes.

I hope you can look at the maturing fish with different eyes now, don't cull too early and select strictly on males with fully colored fins, less tissue between the swords and no bent swords. My fish sometimes showed the next inbreeding depressions: a nod in the tail, seen from above, near the last scales near the caudalfin and a big almost blown up belly when maturing.

Stoerzbach Red Fin Doublesword

A Stoerzbach doublesword with red fins. It may be a blond guppy as well.

Finn Bindeballe photo.

Pied Blue Guppy

Stoerzbach Snake. Photo and guppy by Philip Shaddock

This strain emerged from a cross between a Stoerzbach Metal Swordtail and an X-linked Lace Snakeskin. You can see that the snakeskin trait is somewhat expressed in the mottled appearance of the body and fins, as well as the yellow platinum color. There is an overall blue metallic color from the Stoerzbach. The fins show the expression of the swordtail genes.

I conducted this cross to see if the formula for a Micariff is the combination of the snakeskin and Stoerzbach genes. But the F2 male looks only *somewhat* similar to a Micariff, which has a shiny, yellow metallic color that completely covers the body. See the Micariff chapter introduction.

F2 Green Lace X Full Platinum

The difference here is the lack of the overall blue metallic color due to the Stoerzbach gene.

What is interesting about this phenotype is that a similar phenotype appeared in a cross between a coarse snakeskin and a Yellow Full Platinum. This means that the Stoerzbach gene may not be necessary to the phenotype, but rather a yellow platinum gene inherent in all snakeskins may be the significant factor.

13 Micariffs

Micariff. Picture by Philip Shaddock

Other common names include: Sunset Guppy, Yellow Tang, Tequila Sunrise

The guppy commonly has a light yellow metallic color.

According to the American breeder Mike Khalid, who originally came from the country where the Micariff was developed, Sri Lanka, and who personally knew the designers of the strain, the name "Micariff" is a combination of the names of the two individuals who developed it: Michael Cole and Denis Ariff. Although you often see the name spelled Mikarif, it's correct spelling is Micariff. The Micariff is sometimes known as the "Yellow Tang" guppy, a name given them by Frank Orteca in 1995.

The Micariff began life as a commercial farm-raised guppy, and variations of it often show up in stores. The store-bought version is selectively bred for a huge body and a fan tail, with the dorsal not

well developed, like most farmed guppies. This has somewhat sullied its reputation among fancy guppy breeders, but its popular metallic yellow look has given it a home in some top breeders' tanks.

Another version of the strain seen in pet stores and often kept by even advanced hobbyists has a white, shiny metallic body and red fins or yellow fins. A version with red fins may be known as a "German Sunset" or simply Sunset.

Genetics

German breeders believe the Micariff is a combination of a homozygous autosomal recessive gene Stoerzbach metal (ss) in combination with a homozygous snakeskin gene:

Males - $X^{Ssb\ Sst}Y^{Ssb\ Sst}$ ss

Females - $X^{Ssb\ Sst}X^{Ssb\ Sst}$ ss

According to these sources, in crossing with other strains the first generation usually yields snakeskins, meaning the F1 is heterozygous for the snakeskin gene. Only those individuals in the F2 generation that are homozygous for the snakeskin and Stoerzbach metal genes show the characteristic metallic phenotype.

My own reproduction of this cross did not produce the classic Micariff shiny metallic body. The picture below shows an F2 of a cross I did between a Stoerzbach Metal Swordtail (male) and Kaden X-linked lace snakeskin, both German strains.

F2 Stoerzbach Metal Sword male X Kaden X-linked snakesking female. About six weeks old.

As you can see by comparing this guppy with the Micariff at the top of this entry, the Stoerzbach cross produces a thick, uneven, spotty metal guppy, not the smooth, silky metal finish of the Micariff.

In one individual of this type, I saw telltale signs of the snakeskin pattern expressed in the fins.

Interesting to note is that this phenotype appeared in a different cross, between a coarse snakeskin and a Yellow Full Platinum. The difference is that the guppy shown here developed a definite bluish cast as it got older, suggesting the presence of the Stoerzbach gene.

The French breeder and author Ronan Boutot has told me that he thinks the Micariff requires the presence of the half-black gene.

Apparently many Japanese breeders do not consider the Micariff guppy to have a gene unique to the strain, but rather a gene found in a number of strains. The Micariff gene is the "solid" (ss) gene found on many Japanese strains. It is autosomal. The Japanese "solid" gene is not what the name implies, a monochromatic guppy. Rather the English word "solid" transcribes to "shining" for Japanese breeders.

The author of the Aqua-Farm Japan book calls the Micariff gene the "material" gene (mm). However Bruce (Hsueh Tseng-Biao) from Taiwan tells us that the original word was probably "metallic." In transliteration from English to Japanese, and then to Chinese, metallic became material. The author of the Aqua-Farm book asserts that the Japanese Full Gold strain has the same metallic gene as the Micariff. The question remains: does the Micariff have the Metallic Gold (Mg) gene?

I have combined the Mg and snakeskin genes and *not* produced a Micariff. So it is not the Mg gene.

I currently believe that the Micariff has its own gene, which I will call "solid" since it may very well be the gene identified by Japanese sources. Since the gene symbol "s" is already used by the Stoerzbach gene, I will give it the designation "so." So the genotype of the Micariff is:

X $Y^{Ssb\ Sst}$ soso

Where Ssb = snakeskin body, Sst = Snakeskin tail, so = solid metal gene

The Micariff has been used to create Yellow strains or add yellow to such strains as the Blond Moscow. Luke Roebuck has said that the IFGA blond (IFGA incorrectly calls it gold) HB Yellow makes a suitable cross with this strain. I think the yellow color comes from

the snakeskin side of the Micariff cross.

Orange Micariff

Orange Micariff. Philip Shaddock

This guppy may not be a Micariff! I have temporarily put it in this category until such time as I can verify its genotype.

Breeders Comments

Mike Khalid

Mike Khalid has bred Micariff males to blond (bb) (U.S. gold) red females. This produces 100% yellow guppies! The question arises: is it necessary for the yellow to be dominant over the red to produce the metallic yellow phenotype of the Micariff?

14 Red Guppies

This chapter includes full red guppies and guppies with red fins.

I have studied Full Reds fairly closely and reported my findings extensively in the Guppy Color Manual. I will briefly summarize these findings here.

The most interesting question you can ask about a Full Red is "what makes them all red?" Various people have tried to answer this question. Some suggest there are up to six different genes involved, some suggest just one. I believe it is the case that both views are correct for reasons I outline below.

Often when you outcross a Full Red female to another non-Full Red, you get males that are only partially full red. At other times you get Full Red males in the very first generation. Why?

The theory that Full Reds are due to multiple genes is based on cursory observation. Red when it appears as spots on the body are Y-linked. There is heavy selection for red spots on wild guppy males. According to a theory originally proposed by the American breeder Dr. Larr there are at least six different red genes, accounting for the variation you see in the color on different red guppies. According to this theory, there is not a single gene making the entire body a single red color. The more red genes involved, the redder the guppy. The fewer red genes the pinker the strain.

However against this theory is the evidence that you can create a Full Red male in one generation of an outcross between a Full Red female and a non-Full Red male. My own crosses indicate that it is indeed possible to create a full red male using only full red females...with the caveat: providing you are using a neutral male...neutral in terms of the full red genes that is. The question becomes what genes prevent the expression of the full red genes.

My current theory is that the full red gene is autosomal but in order for it to be expressed it requires sex-linked genes. This is in fact true of all color genes. The sex-linked genes determine where the color gene is expressed and to what extent it is expressed. An example is the gene that blackens the half-black pattern. When that autosomal black gene is expressed in the Moscow instead of the half-black guppy, it is expressed throughout the body, creating a full black Moscow. In the case of an outcross to a strain X-linked for the Platinum gene, you get a Full Platinum. The same variation in outcomes is also the case for the full red gene. Whether or not you get a Full Red guppy depends on the outcross male.

An interesting question is what happens when you go in the other direction, a Full Red male to a non-Full Red female. There is a difference in terms of the expression between some genes when they are is X-linked versus Y-linked. Theoretically it should not matter where the gene is, X or Y. But I think a gene under the influence of a Wingean supergene can have different expression in the male and female. (If it is in the Wingean supergene it probably has mutated to a dysfunctional form in the female...)

Winge studies and my studies of Moscow genetics suggest that it is important to take the male into account. Moscow "normal" black for example is expressed differently in Moscow males and females.

Females tend to be normal grey whereas males tend to be blacker. This is because of the presence of the Moscow gene in the Wingean supergene (where the the wild pattern genes are found in the SDR or Sex Determining Region of the male). Full Reds sex-linked genes are probably outside the Wingean supergene, so they can readily cross-over. In females it is partially expressed, probably because females have low level testosterone.

Another factor to take into account is that the body and fins can be colored differently. You often get strains that have red fins and a body with a different color or pattern.

Red Pigments

There are actually two color pigments involved in guppy red, a carotenoid red and a pteridine red (see the *Guppy Color Manual*). Since carotenoid red has to be acquired from food, and it has health benefits, female guppies are attracted to red spots on male guppies. Rich red guppies significant healthy mates. Where carotenoid food sources are scarce, male guppies can simulate red carotenoid with pteridine red.

Yellow color cells and red color cells are biochemically closely related. Red and yellow pigment are known to be in the same color cell in some animal species. The guppy Magenta mutation (discussed in the Magenta chapter) causes yellow color cells to develop as red color cells to varying degrees. Since Full Red strains can vary between very orangey strains to purplish strains, the Magenta mutation offers evidence that the continuum of color is based on the activity of a single protein, or a gene involved in the manufacture of a protein.

Feeding a carotenoid rich diet, such as brine shrimp, to Full Reds can alter the depth and tone of the red color.

Full Red

European Full Red guppy. A fine example photographed at a Danish guppy show by Finn Bindeballe.

The Full Red guppy may not have a single origin, and mutations for the red head could have occurred independently in Asia, the U.S. and Russia. However, one theory is that the original red head mutation may have occurred in Russia and then made its way around the world undetected. Apparently the first full reds to appear in Europe arrived in pet stores from Moscow.

There is some evidence that the red head Full Red descended from Moscows. I have created Full Red Moscows in the F1 by crossing a Midnight Black Moscow with the blond gene with a blond female Full Red. My Chiasson Full Red line was entirely X-lined red.

A Full Red guppy is red throughout its body, including the belly. The Coral Red Double Sword guppies with red heads are also full red, but they are treated as a separate topic and classified as metallic red guppies. Crossing a Coral Red Double sword with a red delta female

produces a full red guppy.

Genetics

Breeders attempt to distinguish between American and European Full Reds, but I think this dichotomy is false. The difference between American Red Deltas and European reds derived from Coral Red double swords is supposed to be that American full body reds are said to be autosomal recessive, while the European reds are Y-linked. However my own experience with the American Chiasson Full Red was that it was both X-linked red and autosomal. So it may be the case that the Europeans and American breeders are both right and wrong! The Full Red is both sex-linked and autosomal.

Breeders Comments

Hans-Peter Neuse, European Full Reds

Hans-Peter Neuse gives the following advice about breeding his European Full Red line: "The color is dominant on the Y-chromosome, but the color is very, very difficult, when you make crosses. You will loose much of the intensive red. The females are mid-sized, the best have a red backside, with a lit bit of blue in the caudal fin. I never make crosses between grey reds (because of black spots on the caudal fin) and my reds. The best way to improve your strain is to make crosses with normal blond red females. You will get some very big ones! Then you have to select for improving color. I know, it's a long way to go to get satisfying good results, but it's worth it!"
On the former GKR forum he says: "For all the years I´ve been breeding

Full Reds not one yellow version appeared in my lines. Maybe one reason could be, I carefully avoid using females with yellow in the finnage for breeding! I prefer females with blueish fins, like the female shown above."

Breeders Comments

Edgar Chiasson, American Full Reds

Edgar Chiasson is an American breeder.

A Chiasson Full Red guppy is red throughout the body, including red in its belly. Chiasson developed his full reds from Dr. Jim Alderson stock that were showing grey on the stomach area, not the normal white. He worked the red into the stomach area.

He has reported that the full reds do not cross very well with normal reds. The red in the stomach area is apparently lost.

Blond Chiasson Full Red (Philip Shaddock)

The "six red genes" theory is disputed by Ed Chiasson since his test crosses show that the color is not multigenic and additive.

Ed also does not believe red is a dominant color. "Every time I have out crossed to a non-red you get a blending, muddy or blotching of color. I have out crossed both ways to HB Pastel. In crossing to yellow you get orange streaks, always some evidence of that color, much like a Micariff in its red/yellow version. I out crossed to Pingus. You get a pink-like red but looking more like a red, not a Pingu.

My observations have been that the color is not dominant but rather is co-dominant with other colors." Ed has also said that his inbred reds occasionally throw yellow guppies.

Blond Half-Black Full Red

This European standard Blond Half-Black Red is interesting for the red on the head. According to Dr. Petrescu-Mag Ioan Valentin, Blond Half-Black Reds have the following characteristics:

- have no black in the fins but rather a pure red,
- express only weak intensity half-black in both males and females,
- have immaculately red, blue, or green tails in females

Picture courtesy Finn Bindeballe. Taken at a Danish guppy show.

This must be a cross between a Full Red and a Half-Black strain, such as a Half-Black Red.

Albino Full Red

Andrew Lim's spectacular red.

This is the albino version of the *Full Red*, a very popular version because it suppresses black color. This is an orange red morph.

ATFG Albino Full Red

The ATFG Albino Full Red is a purple red, showing that reds can can vary between an orange red and a purple red. I have long thought

this may reflect the different forms of red pigment, carotenoid red in the case of the more orange red and pteridine red in the case of the more purple red.

Albino Full Red Swallow

Rull Red Swallow. Picture and guppy by ATFG.

This variation of the strain has swallow fins, popular in Asia.

Marlboro Guppy

Marlboro Guppy. Guppy and Picture by Vladimir Storozchev

The strain was developed by the Russian breeder Vladimir Storozchev. He spotted it in a tank and further developed it. Smokers will recognize the reason for its name immediately. The bright red and white metallic colors are reminiscent of the packaging for Marlboro cigarettes. They are a very popular brand in Russia.

Genetics

The guppy appears to have at least five genes.

1. Full Red. The full red gene appears to give the guppy its background color.
2. White Platinum. There is the white platinum color, which is shown to be X-linked on the female. See the white metallic area across the top of her peduncle?
3. White body gene? The third dimension to this guppy is the light white color you see in the rest of the female's body. It seems to be missing the yellow base color.
4. Red Tail gene. Notice the red in the female's caudal fin. That indicates she has the red tail gene.
5. Glass Belly allele? If you look at the female's gill plate and the area around her gravid spot, you will see there are missing silver iridophores. It may be an allele of the Glass Belly gene.

Albino Glass Belly Red Speartail

Picture by Andrew Lim

The origin of this strain is China.

Description

This speartail strain has the glass belly gene, making the belly area

transparent. It also has the albino gene.

For information on the yellow and red color cells, please see *Xanthophores / Erythrophores: Yellow and Red Color Cells* in the Notes section.

Genetics

The transparent belly trait is autosomal recessive. It has been applied to other strains. For an extensive discussion the Glass Belly trait, see the entry for *Glass Belly Panda* (in the Pink Chapter).

Mosaic Red Fantail

Mosaic Red Fantail. Photo: Philip Shaddock. Taken at an IFGA show!

This particular fin shape is called "Fantail" in Asia, marked by its broad vertical size, relatively short length, and rounded edges. The mosaic pattern and the caudal fin red color are often found together.

Genetics

The variegated pattern (called Mosaic in Asia) has been studied by the Singapore scientist Violet Phang.

> **Genetic Basis of the Variegated Tail Pattern in the Guppy, Poecilia reticulata**
> Gideon Khoo, *et al.*
> ZOOLOGICAL SCIENCE 16: 431–437 (1999)

The variegated allele (Var) is dominant, and according to Phang

readily crosses over. It can be X-linked or Y-linked. The fantail gene is usually X-linked. The genotype for this guppy is as follows:

$X^{Var\ Fa}Y^{Rdt}$

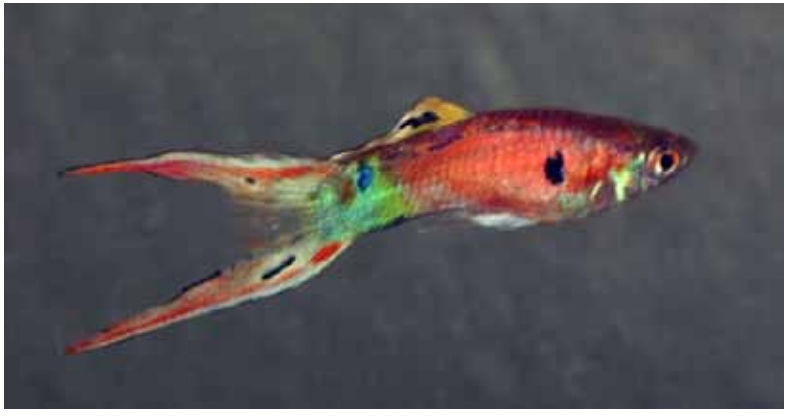
Where Var = Variegated; Fa = fantail; Rdt = red tail.

Blond Big Dorsal Red Tail

Big Dorsal Red. Photo by Andrew Lim

This guppy is said to come out of China. The dorsal is exceptionally full and fan-shaped. The first big red dorsals were said to be very fragile. This is a blond guppy.

Coral Red Doublesword



Coral Red Doublesword. Photo by Finn Bindeballe

This strain has a coral red body combined with the Emerald Green Iridescent (EGI) pattern. It is said to have originated from the Vienna Emerald Green doublesword strain.

The emerald green iridescence spreads into the front of the body. Notice the black stripe across the top of the front of the body and in the top part of the peduncle. These are also characteristic of the Vienna Emerald Green strain. They have a blue or greenish blue metallic color on the lower part of the peduncle, sometimes stretching into the belly area, probably due to the EGI gene complex.

The black spot in the front of the body is characteristic of the Vienna Emerald green strain.

Genetics

This guppy's genotype would be:

$X^{Ds}Y^{Ds}$ Co SmIr

Where Ds = doublesword genes on both the X and Y chromosomes, Co = coral red, SmIr = Emerald Green Iridescent.

Robert Gall, a breeder of Lazulis and Coral Red, thinks that the two strains might have related genetics. See his Breeders Comment in the *Lazuli* strain entry. Robert has also told me that there is an X-linked coral red. The strain includes the platinum gene.

Platinum Firetail Full Moon

Platinum Firetail Full Moon. Guppy and photo by ATFG.

This appears to be a Full Platinum guppy with red fins. The red and black color in the peduncle is possibly the partial expression of the half-black gene that is part of the Full Platinum makeup. The red fins have the full moon tail shape.

15 Half-Black or Tuxedo

The popular half-black body is called "tuxedo" in Asia. The gene is sex-linked and dominant to the wild type. It takes its symbol (Ni) from the scientific name for the mutation *Nigrocaudatus*.

Classic half-black yellow.

As I have said in other chapters of this book, and explained in detail in the *Guppy Color Manual*, there are actually two genes necessary to the expression of the half-black pattern. There is a sex-linked gene and an autosomal gene. The sex-linked gene determines where a a pattern is expressed and to what extent and the autosomal gene determines the color. The black gene that is expresed in half-blacks is called the Onyx gene.

In the scientific literature there are two forms of the Nigrocaudatus gene recognized, NiI and NiII. These are treated as different sex-linked genes. However I think there is actually two different autosomal genes involved, or perhaps two different alleles. Because the two genes are intimately associated in the network of genes responsible for the half-black pattern, NiI and NiII have been erroneously defined as sex-linked genes. In all probability the gene I call the Onyx gene is in fact the NiII gene, producing very dark black patterns and very dark females. The NiI gene is a different autosomal gene, or more likely an allelle of the NiII autosomal gene.

I tend to fail to distinguish between the two genes in my putative genotypes. I will identify the half-black gene as Ni (*Nigrocaudatus*).

There are other color half-body patterns.

Japan Blue

The Japan Blue may be simply a combination of the same sex-linked gene as the half-black, with an autosomal gene that causes the pattern to develop with blue iridophores instead of black melanophores.

Some phenotypes involve the half-black gene but do not express the black color. An example is the Full Platinum. (See the chapter on this strain.) This adds additional evidence to the theory that the half-black pattern is actually due to two different genes, sex-linked and autosomal.

The half=black pattern is widely found to be X-linked. But it is a

gene that crosses over.

Evidence For The Two Gene Theory

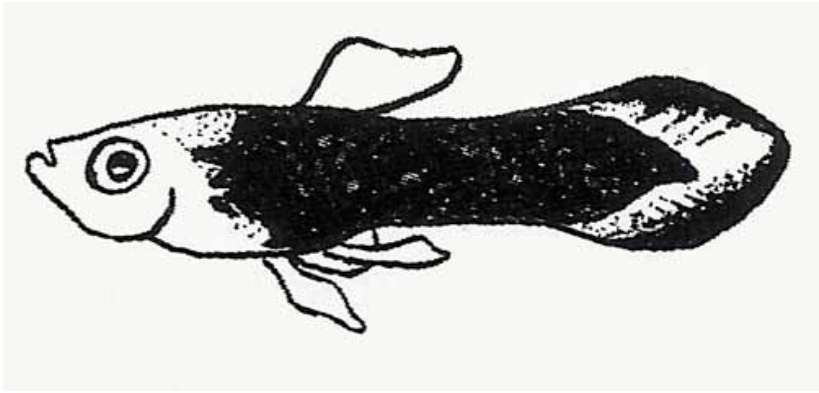
What set me on the path to this shift of paradigm from a single to a two gene theory was a comment in a Penelope Nayudu paper from 1979. (See *Genetic Studies of Melanic Color Patterns and Atypical Sex Determination in the Guppy, Poecilia reticulata*, Copeia 1979, 2 pp. 225-231, and *Cytological Aspects and Differential Response to Melatonin of Melanophore Based Color Mutants in the Guppy, Poecilia reticulata*, Copeia 1979, 2 pp. 232-242.) Nayudu in Genetic Studies (p. 230) notes that the intensity of the half-black pattern is affected by other genes, and speculates that these are probably autosomal genes. So the black in the half-black pattern is not due to the same gene as that confining the pattern to the half-body area (it is sex-linked). It is a separate gene. This is a blow against the paradigm of a single half-black pattern gene determining the color of the peduncle. The reference to this black gene is over three decades old. The Y-linked half-black gene (NiI or NiII) might not be black at all.

The moment of Eureka came when I discovered you can make a Black Moscow using a half-black female with the Onyx or NiII gene. So while the black color is restricted to the peduncle in the half-black, the Moscow allows the black color to cover the whole body.

Area of Coverage

Nobody has successfully created a full black guppy by selectively breeding the half-black pattern to cover more and more of the body. A spontaneous full black mutant from half-black parents has not occured...although the Moscow may indeed be precisely that fish. As I note in discussing the Moscow in the *Guppy Color Manual,* I believe the Moscow has a defective form a gene that suppresses color in the front of the guppy body, making the half-body gene, like the half-black, the norm rather than the exception.

In fact the half-black pattern is not confined to the body. Most people think that the half-black guppy is one with a black peduncle and the fins can be a different color. But if you look at the first descriptions of the half-black guppy, the black extends into the caudal fin. Here is a picture the Russian scientist Kirpichnikov drew of the half-black pattern (nigrocaudatus is the scientific name) three decades ago.



Kirpichnikov's half-black guppy

For a long time I wondered what happened to the black on the caudal fin in the modern guppy. Was it bred out? It was not until I crossed a half-black Yellow guppy with a wild male that I discovered something amazing.

The half-black yellow I used in the cross is shown at the top of this article. Notice how yellow the fins are...there is no black.

Now look at the F1 male from the cross.

F1 male who is the result of a wild guppy male cross to a half-black yellow female.

Compare this F1 male to the Kirpichnikov illustration. What you see is the pattern of the half-black gene in the caudal fin. It is almost a perfect replica.

There is also some black in the caudal fin. The wild male I used had no black on the body, except the wild type grey color.

The conclusion I draw from this is that the so-called half-black pattern is a "full body gene" in the sense that is has the potential to be expressed anywhere on the fins or the body, which is exactly what happens in the case of the Black Moscow. It's expression as black color is suppressed in the fins in the case of the half-black yellow and is suppressed in the case of the half-black strains but not the Moscow. To be more precise, I would say that the black color of the half-black complex of genes has the potential to be expressed anywhere in the body.

It was later that I discovered that the half-black pattern is expressed as white and yellow color when combined with Full Platinum guppy genetics (see that chapter.)

Half-Black Dominance

Dragon Head Guppy. Notice that the snakeskin pattern has become a dot pattern in the fins. You can barely notice the snakeskin pattern in the front of the body.

The Half-Black "gene" is widely considered to be dominant, and in the wild guppy cross I did it certainly was. But as in all cases involving two genes competing for expression, whether a gene is dominant, recessive partially or co-dominant depends on what gene it is com-

peting against. In the case of the snakeskin the half-black genes appear to be "dominant" in the half-body area and "co-dominant" in the rest of the body, including the fins. This produces the "dragon head" phenotype. I tend to be circumspect in my use of the terms.

Breeding Half-Blacks

As mentioned earlier, the half-black gene is usually found on the X-chromosome, although some rare strains may have the gene on the Y-chromosome.

The female should be picked for form and intensity of half-black pattern. Select the females with the thickest peduncles and the best overall shape. The usual advice is to select the females showing the darkest half-black pattern, regardless of fin color.

Half-Black Yellow

HB Yellow. Picture by Philip Shaddock. This individual has a bit of yellow streaking in the top part of the caudal fin. This is considered to be a fault in a show guppy.

The Half-Black Yellow strain was originally developed by Gerhard Gellrich from Frankfurt in Germany in the 1960s, where it is small compared to its American descendants. It was imported to America at the beginning of the 1970s and was probably crossed with the large-bodied Half-Black Pastel females to purify the yellow color and produce larger versions. The strain was exported to Japan from Germany where it became very popular. It was eventually lost in Germany, so the Half-Black Yellow was imported back to Germany by in the early 1990s. Gellrich also developed the HB White.

Genetics

Most Half-Black Yellow strains have the half-black allele (Ni) on the X-chromosome.

Essentially it is a guppy that combines the half-black genes with the Platinum fin gene, so its genotype would be.

$X^{Ni}\ Y^{Plt}$ *where Ni = half-black gene and Plt = Platinum fin gene*

The half-black yellow strain is the basis for many other variations, including the Full Platinum. When combined with the Platinum and Metallic gold genes, the black color becomes white and yellow.

This accounts for the pure yellow tail, which normally would have black in it from the half-black genes. In a cross I conducted with a feral guppy, the natural expression of the half-black gene in the tail emerged in the F1 of the cross.

The yellow caudal is actually part of a two layer color cell system with white leucophores below yellow xanthophores (yellow color cells).

Breeders Comment

The strain is difficult to breed to show quality standards because the color yellow is easily overshadowed and is darkened by intermixed black pigment. Yellow guppies have an abundance of xanthophores, (yellow pigment cells). After repeated inbreeding, the light yellow may be difficult to maintain. Half-black pastels are commonly used by show breeders to clean up the fin color of the half-black yellows by various crossing techniques.

Make sure you choose females for breeding that have pure yellow fins.

Another problem that crops up with the Half-Black Yellow strain is that the black tends to bleed into the caudal fin if inbred too long. (This confirms that the half-black gene also affects the caudal fin.) Size tends to dwindle quickly with successive generations so it is recommended that the breeder keep at least three lines of these going at once: one line for color, one for shape and one for size. Many people won't work with this strain because of the high number of tanks required to maintain it to show quality standard. Some believe it requires at least 18 tanks to properly maintain it to show standards.

Some breeders recommend using Half-Black Pastels to "clean-up" the yellow on this strain. You need to find strains that have the half-black gene on the Y-chromosome and not the X-chromosome. In doing a cross to avoid the half-black pattern, use gray females from these strains. However, this is a risky cross if you do not know the genetic background of the two strains. The problem is that the Half-Black Pastel color genes are dominant to the Half-Black Yellows.

Some breeders report good success crossing gold bodied Half-Black Pastels to the strain of Half-Black Yellow that needs improvement. Try to use the Half-Black Pastel males that have yellow in the fins for best results. If the fry from the cross grow up and look good and you are satisfied, breed these f1 fry males back to your original line females and start your new lines from those females or breed the F1 siblings from the cross to each other and start your two lines from there. If you have the tank space, you can breed back to your original

line and breed the siblings to each other and choose the fry that give the best results. Most people who show their half-black yellows and win, will also have a compatible half-black pastel strain on hand to cross into whenever they see a decline in their half-black yellows.

Half-Black Red

The challenge provided by this strain is maintaining the intensity and density of the red and the deep black of the half-black pattern simultaneously while selective breeding. Black spotting creeps into the dorsal, and the red fins can become muddied, developing brown tones. Similarly, the half-black pattern can become weak, washed-out and lose its clear line of demarcation between the front and back parts of the body at the dorsal leading edge. You can see in the picture that the half-black pattern has spread into the front part of the body.

HB Red. Picture by Philip Shaddock, taken at a guppy show.

The red color is affected by the food the guppy eats. Foods with carotenoid (which the guppy cannot synthesize *de novo*) help the guppy store red pigment. For example, brine shrimp is said to deepen the reds of Half-Black reds or other red strains. (But a redder guppy may simply be a healthier guppy.) The other chemical in red is pteridine. It is synthesized *de novo*, so it is not derived directly from food.

Genetics

Red Genetics

See the chapter on Red Strains for a discussion of the factors affecting red color in guppies.

In some strains the best female is not the one with the darkest red fins, but rather with pink or lavender fins with a slight mosaic pattern.

Half-Black Genetics

Improving the red color is usually accomplished by breeding blond-bodied (bb) Solid Red males with gray-bodied Half-Black Red females. This produces an excellent F1 generation, all half-black. The males are then bred back to original Half-Black females. It's critical that the female with the darkest half-black pattern be chosen, since this cross does tend to lighten the half-black pattern, even as it is cleaning up the red color. The females from the F1 generation of this cross can be used to create a new gray-bodied Solid Red line. They are bred to homozygous (pure) blond (bb) Red males (called gold in America). The F1 drop of this cross will yield about 25% gray-bodied (bB) Solid Red of excellent quality. Half-Black Reds are also crossed with Red Albinos.

Crossing a male Half-Black Red with a Red Albino female produces an F1 generation that is gray-bodied Solid Red (assuming both parental strains are homozygous). The red will be rich and dark. The fins will be excellent. Crossing the other way (male Red Albino to female Half-Black Red) is not as productive. The F1 generation is all Half-Black red. If spots have been a problem with your line, and the parental generations were good, this cross may clear up the spots.

Using bi-color or multicolor guppies with red in them is not usually a good idea, unless you have a long time horizon and lots of tank space. The pattern, once bred into your line, is very difficult to get rid of.

Glass Belly Half-Black Red

ATFG's combination of the glass belly gene with a half-black red shows what you can do with guppy color when you are creative. The red around the gills is due to the glass belly gene, which removes silver iridophores from the gill plates, allowing the red color of oxygenated blood to show through, complimenting the red in the fins. There is also a yellow color in the front of the body from another gene.

ATFG's Glass Belly Half-Black Red

Half-Black Purple

HB Purple.

Most HB Purples that you see on the show bench tend to look very dark, almost black. There is a lot of black pigment underneath the purple pigment. The color purple is composed of red color mixed with reflected blue light.

Color Structure

The color purple is created by two color cells in the skin:

- blue light reflecting iridophores
- red pigment color cells (erythrophores)

The iridophores are in the middle layer of the skin. The erythrophores are above, acting like the color gel on theater lights. The mixture of blue and red light produces purple color. Because these two colors segregate separately, the quality of purple is affected by the density and distribution of these two types of color cells.

Breeders Comments

The strain is cross-compatible with blues and greens. Green is a somewhat better cross than blue. The cross to blues tends to produce dark Half-Black Blues or almost black Half-Black Purples.

One breeder suggests that the cross between Greens and Purples works both ways. Purple is dominant over green. The cross also produces a portion of Blues.

To improve the Purples, cross a Purple male with a Green female. Back cross to the Purple line, choosing a Purple female from the hybrid cross. To do that, darken the lights in the fish room and shine a flashlight on the females. There will be green and purple females, showing green and purple crescents at the base of the peduncle respectively.

With regard to the Half-Black Purples, the purple color tends to become darker as the breeder selects for a dark half-black pattern. If the breeder does not maintain one line for light purple color on the fins and another line for dark half-black pattern, he or she might find themselves breeding the light purple color right out of the strain. They will then have to go to an out cross to try to lighten the purple color.

As is the case for most Half-Black strains, the female is key. In most Half-Black Purple strains, she carries the half-black gene. She can also affect the darkness (blackness) of the male's tail. The breeder should choose females who have the darkest half-black pattern and the lightest tails. Better still is to maintain two lines, one focused on the half-black pattern, the other on the light purple color. Cross one to the other to correct problems as they arise.

The best out cross is to a solid Purple strain. A Purple male is bred to a Half-Black female with the darkest black half-black pattern and the cleanest tail. This hybrid cross can produce show winners.

Half-Black Pastel

This HB Pastel was part of a tank entry that won first place in a guppy show.

The first Half-Black Pastels came as Half-Black Whites from a breeder in Germany (Frankfurt), Mr. Gerhard Gellrich. It has been said that they originated out of Half-Black Yellows. He shipped his new strain to the U.S. sometime around the end of the sixties. At the same time he shipped some to Japan. The modern strains have descended from these originals. The Japanese developed their "lily white" tuxedos from this Gellrich strain.

The Half-Black Pastel may have originated out of Europe, but its huge size and spectacular, showy fins were developed in America. It is a favorite among breeders in North America. A single tank of Half-Black Pastels can draw attention from across the room.

The Half-Black Pastel is basically a gray or gold bodied half-black guppy with white fins. There are blue iridophores in some strains, giving them a pale bluish tone. The half-black pastels that have done the best on the show bench over the years are the type with pure white fins, although those with the bluish hued white fins do well during certain show years as demonstrated by the one pictured above.

This particular strain has a red spot in the front of the body.

Genetics

This strain has a number of genes in it's make-up, including the half-black gene that gives it the half-black peduncle. Most HB pastels seen on the show bench are the F1 generation hybrids from recent out crosses, since this strain tends to get very small, very quickly without the regular infusion of new gene stock.

This strain is used to "clean up" Yellows. The two strains have been interbred enough so they are genetically closely related.

The genetics of the fins is probably similar to half-black yellows and involve Full Platinum genetics.

Breeders Comments

The Half-Black Pastels have perhaps one of the tightest and most stable genetics. They are often used in crosses because of this. However, ironically, they are not easy to breed because the purity of the pastel color on the fins is easily lost.

A problem plaguing many American Half-Black Pastel lines is infertility and a decrease in size after a couple of generations of close inbreeding. Some breeders use the blond (bb) Half-Black White to increase the size and fins of their grey-bodied line and to fix the fertility problem. A blond Half-Black White male is bred to a grey Half-Black Pastel female. This produces washed-out offspring. The best of the males are selected from the cross and bred to blond Half-Black White females. This is said to produce a bigger, more vigorous line.

Half-Black Pastels benefit from a good line breeding program. At a minimum keep two lines going, crossing brother to sister for three generations and then crossing the lines. When selecting male breeders, the largest bodied males are not the best choice as they often have fertility problems. Use the largest females to maintain size. Show quality selective breeders recommend that the aquarist introduce their male and female breeding stock to each other at the three month mark of development, as older virgin females become harder for the males to impregnate.

The Half-Black gene is most often found on the X-chromosome.

The Half-Black Pastel male is sometimes bred to lace Snakeskin females with the snakeskin pattern on the X-chromosome. This produces Half-Black AOC offspring with poor spotted patterns. The American breeder Luke Roebuck prefers to do the cross the other way. He suggests the lace snakeskins are preferable to those showing

the Cobra pattern, as the lace pattern is more recessive. "A good Russian Metal Lace may be even better because the metal head would control the surface area expression of the half-black color to about 50%, which is desirable." Luke is referring to the member of the Moscow family that has the Moscow blue on the front part of the body and Snakeskin pattern on the second half.

Blond Half-Black Pastel (White and Yellow Pastel)

Luke Roebuck White Half-Black White

Yellow Half-Black White. Luke Roebuck

The White Pastel is basically a half-black white guppy with the blond mutation. What you do see is the wild red spots on the guppy.

Luke comments on the White and Yellow Pastels: "they came from a variant from Rosenberry from the Pasadena Texas Guppy Club. They were crossed to Alderson HB Pastels. They tend to erase the problems of the original strain dorsal, which had better color than the caudal. fin You can see the "ghost" of the Half black body faintly visible in the males. These fish are maintained by Hermann Magoshitz of Germany as well as myself. Hermann won the WGC 2001 Grand Points overall with the strain. They get fairly large and have great fin shape but can have some dorsal shape problems."

Genetics

The blond (bb) allele is recessive and the body color is inherited like other recessive body colors.

Nine out of ten Pastel strains have the half-black allele (Ni) on the X-chromosome.

Half-Black White

German Yellow Tuxedo. Photo by Andrew Lim.

This is commonly called a German Yellow Tuxedo in Asia.

In 1969 the Japanese imported the Half-Black Yellow from Germany and developed a number of strains out of this stock, including strains

that are still called Half-Black Yellow, even though they do not have any yellow on them. For example the Japanese Half-Black Pastels often go by this name. The German Yellow Tuxedo has been a mainstay of Japanese strains.

The Asian style tuxedos (half-blacks) often include color in the front part of the body. In this case the guppy has both genes for the half-black white patterns as well as the White Saddle gene which spreads leucophores on the guppy's dorsal area.

Genetics

The Japanese love of crossing strains is exemplified in the many Japanese strains that have arisen out of the original German Half-Black Yellow stock. For example, the original strain was crossed to Half-Black Reds. The Neon Tuxedo has silver hues on the back and has a delta caudal fin. The Japanese author and breeder Iwasaki speculates that it is a result of crossing a Red Tuxedo with a Singapore Neon Blue guppy. Iwasaki: "Crossing a German Yellow Tuxedo with a Tiger Bottom Sword produces wonderful silver-backed Red Tail Tuxedos, but the fish are weak, and in the F2 generation so weak as to mostly die out." Iwasaki's reference is to strains that predate 1989.

RREA Yellow Tuxedo

RREA Yellow Tuxedo. Andrew Lim. (Albino Yellow HB)

This is the albino (Real Red Eye Albino or RREA) version of the strain. It would be called an RREA Yellow Tuxedo in Asia.

This version has the white saddle gene.

Genetics

The putative genotype for this strain is as follows:

$XY^{Wt\ Ws\ Ni}$ aa *Where Wt = White Tail, Ws = White Saddle, Ni = half-black, a = albino*

Half-Black Green

HB Green.

In this particular version of the HB Green strain, the females tend to vary from very dark grey to very black.

Genetics

Green color in guppies is due to yellow pigment color cells (xanthophores) and iridophores (blue light reflecting metallic color cells), so green is under the control of at least two independent genes.

This guppy carries the half-black genes. The blackness of the female makes it likely that the HB allele is the NII version.

The green color in the fins of this strain is due to x-linked yellow color cells and iridophores. In a cross I did with a Moscow, a half-black white phenotype segregated out of the cross. Since it could not have come from the Moscow, it is assumed that the X-linked half-black white fin gene (Wt) was used to lighten the fins of the half-black green.

Breeders Comments

Philip Shaddock

As is the case for most Half-Black strains, the female is key. She can also affect the darkness (blackness) of the male's tail. The breeder should choose females who have the darkest half-black pattern and the lightest tails. Better still is to maintain two lines, one focused on the half-black pattern, the other on the light green color. Cross one to the other to correct problems as they arise.

This particular strain of the HB Green guppy has a gene called the Onyx gene (so named by Dr. José René Meléndez Berríos). This autosomal recessive gene is used to deepen the black peduncle of the strain. The females in a drop can vary from a female with a moderately black peduncle to a female that is jet black from the nose to the tail, with only the belly in silver. I have transferred the gene to other strains. A black Moscow was created that does not fade on the judging bench, as well as a "two-tone" black Moscow with a black body and green fins.

Black Half-Black

Black Half Black.

This is a guppy that has black fins and a half-black pattern on the peduncle.

Dragon Head or Leopard

Dragon Head or Leopard.

Also known as a HB AOC in America.

The Dragon Head is the result of a cross between a half-black and snakeskin guppy. What distinguishes it is the partial expression of the snakeskin pattern in the front of the body and half-black pattern on the peduncle. The snakeskin pattern in the fins is expressed as spots or a mosaic pattern.

This is a popular strain and is usually recommended to beginners because its cross-bred vigor makes it hardier and bigger than other strains. It will retain these qualities longer than more inbred strains, and can usually go five or six generations before it needs to be line crossed or out crossed. Typically the black spot pattern is on a yellow or white background, but it depends on the colors of the snakeskin and half-black strains used in the cross.

Genetics

Note that the snakeskin body and fins are due to two separate genes (Ssb and Sst). To produce a Dragon Head, you need to choose a snakeskin line that has both the snakeskin body and fins to produce a Dragon Head with spotted fins.

The genotype for this strain is:

$X^{Ni}\,Y^{Ssb\ Sst}$

Where Ni = half-black gene, Ssb = snakeskin body, Sst = snakeskin fins

The color and pattern of the F1 will depend on what base colors of the two lines (HB and snakeskin) you employ in the cross.

The scientist Dr. Gideon Khoo in Singapore has made an interesting observation about this cross. In a lecture he gave in 2005 at the University of Singapore, he pointed out that the BCP gene (which colors the peduncle and caudal fin black) causes the snakeskin pattern in the fins to become coarse black dots. Indeed, if you look at the picture at the top of this entry, this is what happens when a half-black strain, presumably with the Ni half-black gene, is crossed with a snakeskin. The snakeskin pattern in the fins become coarse dots.

Breeders Comments

A well-established Dragon Head strain should be true-breeding, meaning most of the offspring should be identical to the parents. If you want to make your own Dragon Head, the best cross is a male Snakeskin and a female Half-Black line. This assumes the female has the Half-Black gene.

Luke Roebuck suggests trying a Moscow strain showing the snakeskin pattern on the latter half of the body and a blue "metal" pattern on the fore part of the body." Pay particular attention to the quality of the snakeskin. Some of the older snakeskin lines suffer from a small dorsal or short caudal fin. When you have crossed the snakeskin male to the half-black female, take the best male from the offspring and breed him back to the half-black female line. Once you have your new strain established, every fifth or sixth generation breed a male back to the X-linked half-black female line. This means that to maintain a Dragon Head, you should have room for a second half-black strain. Good half-black strains to use to maintain the white background color on Dragon Heads are blue, purple, yellow or lavender. You may need to experiment with various snakeskin lines to get a good spot pattern on the fins, rather than swirls or splotches of color. This makes it important that you use true-breeding half-black and snakeskin lines to gain control over the variations produced in subsequent generations.

Iwasaki, in Fancy Strains and How to Produce Them, says that in maintaining the Japanese version of the Dragon Head, the Leopard strain, use a King Cobra [i.e. crude pattern snakeskin] female. You can also crossbreed with Yellow Grass, keeping the fry that most resemble the Leopard, and breeding them back to the Leopard. Do not use guppies with red coloration in the caudal fin. Select simple

Leopard females with round, clear tails.

16 Solid Color

Take away the half-black gene from many of the strains in the previous chapter and you are left with solid color strains.

The solid color is not as even and complete as Full Color Moscows or Full Reds. In general the front of the body is weak in the overall color.

American Blue Delta

Solid Blue Photo: Philip Shaddock

The phenotype is a solid blue, with some strains having a strong metallic shininess. The red spot in the peduncle area is typical of this strain. The fact you see a lot of blue color in this guppy makes the distinction between blue and green strains somewhat arbitrary. The difference comes down to the number of yellow color cells that are present and the color temperature of lighting.

Genetics

Since blue color comes from blue reflecting iridophores, and there are many possible types and configurations of iridophores (blue, green, yellow, white, silver) with varying degrees of density and thickness, there is great variance in the quality of the blue.

American Green Delta

This is a Green (called Florida Green) guppy descended from a Gorski green. The bluish color is due partly to lighting. It was shot in full sunlight. Under a flourescent light it would look a lot greener. Compare this guppy to the one below. Photo by Philip Shaddock.

Description

Solid Greens are an old strain. And one of the oldest Green strains is the "Parish Green." This strain was originally characterized as large and hardy, although inbreeding has probably changed that. The breeder Hutter developed a green with a matching dorsal, which was further developed by Regent. Hutter greens tend to be smaller and more brilliant in color, and less hardy. "Parrish Greens" is a term that often refers to guppies with white spotting or streaking in the dorsal, while "Hutter Greens" have come to refer to greens with matching dorsals.

This must be one of the most DQ'd (disqualified) guppies at American guppy shows. The green guppy in the breeder's tank appears under the show lighting as a blue or purple guppy. The reason lies in

the color structures in the guppy's skin.

Parish Green . The two guppies are related. They are both descended from the original Parrish Green.

The green color is a combination of yellow pigment and reflected blue light bouncing off the guppy's iridophores. The angle and color temperature of the show lighting reflecting off the iridophores can change the apparent color of the guppy. Because judges have to evaluate with their eyes, not with their preconceptions, a Green under unnatural lighting conditions at shows often does not show enough green color to qualify. Although there are full body green guppies in other parts of the world, the non-American green tends to be more metallic. The American Green metallic blue is weak and scattered, creating a thinner and duller green. It thins out to grey towards the front of the guppy.

Stoerzbach Moscow showing a metallic yellow green color.

The presence of red spots in the peduncle is typical of the strain.

Color and Genetics

The Solid Green has three main layers of color: black, structural blue and yellow. The black melanophores are at the bottom and act as a sponge for light. The structural blue iridophores are above the black layer and reflect blue light. The topmost layer is composed of yellow color cells. Green is blue light mixed with yellow light. The more reflective color cells (iridophores), the bluer the shade of green. The more yellow color cells, the more yellow the shade of green. And the more black color cells, the darker the shade of green. When the reflective layer becomes thick and slightly disorganized you get a metallic green guppy like the Stoerzbach Moscow above.

These three color cells tend to assort independently in a cross. So the Green Delta is cross compatible with yellows and blacks. Some breeders use Greens to improve the yellow color on Yellow Deltas. This is because the Delta Green has a lot of yellow pigment. In a cross the yellow pigment will sort independently, producing some Yellow Delta guppies with more yellow pigment as a result of the cross.

If you look at the Florida Green guppy at the beginning of this listing you will see that it has yellow color spreading from the base of its caudal fin. I believe this is a form of the Platinum (Pl) gene. It has probably found its way into the strain from its ability to make the guppy look green (blue plus yellow equals green).

Breeders Comments

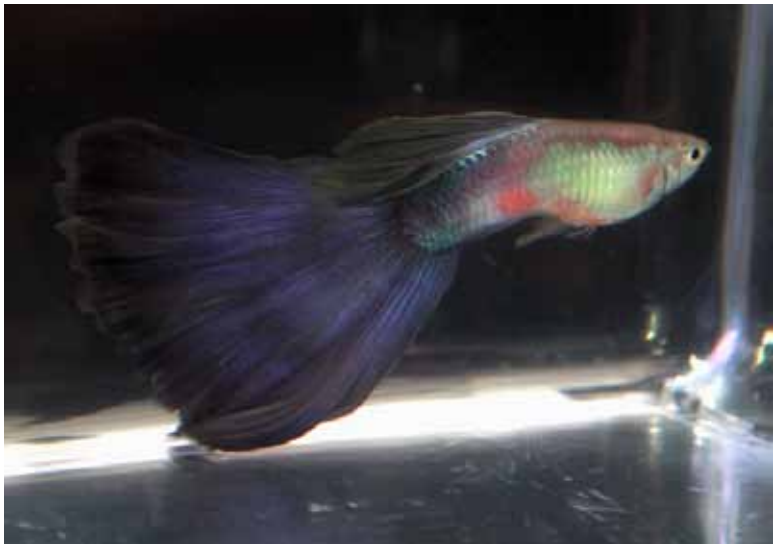
Because of the size and classic fins of the Greens, and because the green colors (yellow pigment and structural blue) are recessive to most other colors, the Green guppy female is often used to increase size and improve fin shape in other strains. It makes a good compatible cross with blues, superior cross with purples, excellent cross with snakeskins and reasonable cross with a Dragon Head. Reds are not compatible with Greens. Crossing with Purple strains darkens the Greens. Therefore, the lightest colored Green males should be crossed with Purple females. Use a flashlight to find Green females in the offspring. The Green females have a green crescent at the base of their caudal fin.

As is the case for most Half-Black strains, the female is key. In most Half-Black Purple strains, she carries the half-black gene. She can also affect the darkness (blackness) of the male's tail. The breeder should choose females who have the darkest half-black pattern and

the lightest tails. Better still is to maintain two lines, one focused on the half-black pattern, the other on the light green color. Cross one to the other to correct problems as they arise.

In crossing with Snakeskins cross a Snake male with a fine lace pattern to the Green female. The snake pattern may be coarse in the first generation, depending on the genetics of the Snakeskin. The usual advice is to cross back to the Snake line in subsequent generations.

American Purple Delta



Solid Purple Delta. Photo: Philip Shaddock

The color purple is created by two color cells in the skin:

- blue light reflecting iridophores
- red pigment color cells

The iridophores producing the blue color are in the middle layer of the skin. The red color cells are above, acting like the color gel on theater lights. The mixture of blue and red light produces purple color. Because these two colors segregate separately, the quality of purple is affected by the density and distribution of these two types of color cells.

Notice the red spot in the peduncle area.

American Bronze (Golden)

Solid Golden Guppy

American breeders call this a "bronze" guppy. But its actual scientific description is "golden." That mutation alters the expression of black in the guppy, creating an exaggerated reticulation pattern in the body and spotted fins. The golden mutation is autosomal recessive.

17 Colorless Strains

This chapter includes guppies with a combination of genes that result in the loss of color. These can actually be a combination of dominant, semi-dominant and recessive alleles.

For an extensive discussion of the removal of color from guppies and the resulting phenotypes, read the *Guppy Color Manual*.

Albino Blau

Photo: Philip Shaddock

This Taiwanese version of the strain has the body genetics (big body and fins) of the American strains and the color genetics of an Asian guppy. It is related to the common Singapore farm blue neon "tuxedo" guppy found in fish stores everywhere. But the use of American genes in combination with Asian genetics has produced a stunner.

It is an albino. This is similar to the Super White strain, but it is also-heterozygous for the Asian Blau gene, rather than homozygous, and it has no blond gene.

Genetics

The particular strain shown above is actually a half-black red that has the Asian Blau mutation. It's genetic makeup is as follows:

XY^{Ni} aa Abab

Where Ni = half-black, a = albino, Ab = Asian Blau

The Asian Blau allele is autosomal dominant. When it is homozygous (*AbAb*), it produces a pale white body with some blue in the fins. When it is heterozygous (*Abab*) it produces a body with yellowish tones and blue fins.

Breeder Comments

Philip Shaddock

You can make your own version of this strain by first crossing a half-black red with any of the strains that have the Asian Blau mutation and then cros to an albino strain. Normally the suggestion would be to use the classic Neon Blue strain found in pet stores. But it has very poor body and fin shape and usually diseased. That is why it is better to start from a half-black red.

The initial out cross (HB Red to Asian Blau) should produce a blue metallic guppy.

You should do a reciprocal cross, male of one strain to female of the other and vice versa. This will help ensure that you get the best body and fin characteristics from the two merged lines. In the F1 of the cross you will get about 100% blue guppies and no red guppies, due to the special nature of the Asian Blau mutation. The blue guppies are heterozygous for Asian Blau gene. In the F2 and subsequent generations you will get a percentage of blue guppies depending on the female you mate with blue male.

The best choice for an albino out cross strain is an albino half-black red or albino full red.

An interesting variation of this cross would be to use a full red rather than half-black red for a fuller bluer color and no half-black ghosting.

Super White

Also known as RREA Super White, Triple Recessive, Genetic

White, Albino White or Albino Super White.

Super White. Photo by Andrew Lim

The Super White is almost transparent, except for some light blue color in the fins (from the presence of blue iridophores) and some silver iridophores in the belly and gills. It has an opaque belly. Compare this strain to the See-thru strain, which has a transparent belly, transparent gills and no silver color in the eyes.

Genetics

The Super White has the Asian Blau gene, which is homozygous. It has the albino and blond mutations. This combination of color genes suppresses expression of black, red, or yellow pigments.

Super White guppies can be created by crossing guppies that carry the appropriate genes: albino + blond (gold in the U.S. and Asia) + Asian Blau (often called blau or brao). The gene notation is:

aa bb AbAb

Where a = albino; b = blond; Ab = Asian Blau

Note that the Asian Blau mutation is homozygous. Homozygous Asian Blau appears to have an affect on all the major classes of color cells, including the iridophores and black color cells in the body. The end result is a guppy noticeably whiter than a non-Asian Blau, albino and blond guppy.

Obviously the question mark here is the necessity for a blond re-

cessive gene. Presumably the albino gene would cause a complete failure of black pigment to be produced. The blond gene causes the melanophores to fail to develop, making them too small to see with the naked eye. With no color cell blocking the path of the light, the guppy is rendered transparent, just as you see in the picture.

The blue in the fins is an expression of the Asian blau gene, which affects the body differently than the fins. The fins tend to have some blue iridophores.

See also the *Albino Blau* strain, which does not have the blond gene and is heterozygous Asian Blau.

Ruby Eye Super White (WREA Super White)

This version of a white guppy has a form of albinism that allows it to partially display melanin in its eyes, called lutino or ruby-eye or wine-red. Courtesy of Uthen Chaichot. Also called a Lutino White.

This is a Super White that has the WREA (Wine Red Eye Albino) gene instead of the albino gene. The WREA gene allows some black pigment to be made. You see this mostly in the eye, which is colored dark red, like a red wine.

See-thru

In 2008 I set out to create a guppy with all the colors genetically removed. The result was the See-thru guppy.

See-thru male. Guppy and photo by Philip Shaddock

See-thru female. Guppy and photo by Philip Shaddock

The See-thru guppy is so-named because it's internal organs are visible. The skin is normally rendered opaque by a layer of silver iridophores in the belly area and a combination of the other color cells in the other areas of the body. The mutations I employed cause the skin to become transparent. The red color seen in this guppy is due the color of blood!

The male has a bit of yellow in the head and at the base of the caudal fin. He is heterozygous for the Asian Blau gene.

Genetics

I published a scientific article in AACL Bioflux that details the development and genetics of this guppy. It is titled: "The See-thru guppy: a transparent fish model."

The two strains that were used to develop this guppy were an Albino Asian Blau strain and a Glass Belly Panda. Here are the three mutations:

- Albino: removes black color
- Asian blau: removes red and yellow
- Glass Belly: removes iridophores and leucophores

This is the genotype of the See-Thru guppy:

aa AbAb gbgb

Where a= albino, Ab = Asian Blau, gb = glass belly

The particular Albino Blau strain I used was a half-black white with the white saddle gene.

Blond See-thru

The female at the top of this picture is a white blond See-thru guppy. She is white because the yellow color cells cannot be expressed when the Asian Blau gene is homozygous. Her black eyes distinguish her from her albino See-thru related strain.

Genetics

The strain was created by back crosssing a male See-thru to one of the See-thru founding strains, a female blond Glass Belly Panda. The two guppies at the bottom of the picture are also blond See-thrus but they are not homozygous for the Asian Blau gene so they show a lot of yellow.

The white female has the following genotype:

bb AbAb gbgb

The bottom guppies are:

bb Abab gbgb

Blond See-thru. Guppy and photo by Philip Shaddock

18 Variegated, Wild and Endler

This chapter includes feral guppies, laboratory guppies and wild guppies. It also includes domestic guppies with the wild type pattern (variegated).

Rio Leao Feral Guppies

Wild Rio Leao Male. Photo Philip Shaddock.

This strain is said to be from Rio Leao near Santa Catarina in the southern part of Brazil. Guppies are not native in this area of South America, so it must be assumed they were introduced into the Rio Leao at some point in the past.

The males have three red spots on the body, plus iridescent blue and green in the peduncle area. The females are colorless. The strain is quite small, as is the case with most wild guppies.

Erfurt Wild Guppy

Erfurt Wild guppy group. Dimitri Farla.

This guppy was released in the heated waters surrounding an energy site in Erfurt, Germany. They have lived there since about 1975. Like many introduced guppies, these fish have reverted to looking like a wild guppy.

There is some variation between males. Some males show small topswords or more green in the body than the fish shown on the pictures. All females are wild type females meaning they are a nondescript grey. The males have slender bodies and almost all males show a black spot just above their gonopodium.

Lampang Wild Guppy

This wild guppy is found in the Lampang Province of Thailand. Notice the striking similarity to the Erfurt Wild Guppy. This guppies obviously come from a common ancestor.

Lampang Province Wild Guppies. Picture by Buncha

Istanbul

Male Istanbul guppies. Picture by Philip Shaddock

I obtained this guppy from Dr. Felix Breden at the Breden Lab, Simon Fraser University. He told me he acquired it from the Max

Planck Institute, which in turn obtained it from a hobbyist breeder. It is supposed to be directly descended from those described by Dzwillo in his 1959 paper on domesticated guppies.

Female Istanbul guppy.

Vienna Emerald Green Swordtail

Vienna Emerald Green Swordtail. Picture by Philip Shaddock. The "emerald green" color shows here as blue.

Sometimes called *Wiener Smaragd*, the German form of the name.

This is one of the oldest breeds of guppies, and the foundation of

most of today's swordtail strains. It was developed in the late 1980's by Austrian breeders and bred to a standard. It made its way to Japan in the early 1990's.

The best double swords are often found on this strain.

A Vienna Emerald Green guppy at a Danish guppy show. Picture by Finn Bindeballe.

According to the European standard for this guppy, the ideal overall color is metallic green. However it often has a golden yellow metallic color in the forebody. (This may be the Schimmelpfennig Platinum gene.) The black pattern on the body is best described with the German word "mäanderförmigen," which can be roughly translated as a "meandering form," having a wavy pattern like a ribbon in the breeze or a river wandering over a plain.

The best examples of the strain should also have a "Peacock Butterfly" (black eye spot with iridescent edge) pattern on the caudal fin. The fin coloring can vary from whitish yellow, red to blue hues (often very pastel) with a black seam at the outer edges of the fin. Genuine Vienna Emerald Greens with these colors are now relatively rare. This strain is now found in lower sword or double sword variations. There has not been an upper sword version of this strain.

The European standard also calls for a vertical pattern of bars in the middle of the body. This is said not be be a Zebrinus or bar gene. It is autosomal.

Genetics

Females of this strain tend to be colorless and are widely used to improve the body shape and fin shape of other swordtails.

This is said to the foundation strain for modern swordtails. The "Old Fashioned" Japanese guppy is essentially a delta tail version of the Vi-

enna Emerald genetics. The Coral Red and Platinum strains are said to be mutations of this strain. Additionally there is a version with blue in the peduncle area, said to be a Y-linked recessive allele.

The strain gets its name from an intense green metallic color at the base of the peduncle, spreading into the rest of the body. It is called the "Emerald Green Iridescent" or EGI. The color is Y-linked, making it a kind of genetic marker, since the trait is passed on from father to son. It can be X-linked.

The Schimmelpfennig Platinum sword is another mutation out of this strain. It has a blue background color similar to the blue variants of this strain.

Single Sword Vienna Emerald Green

Single sword VEG. Picture by Philip Shaddock

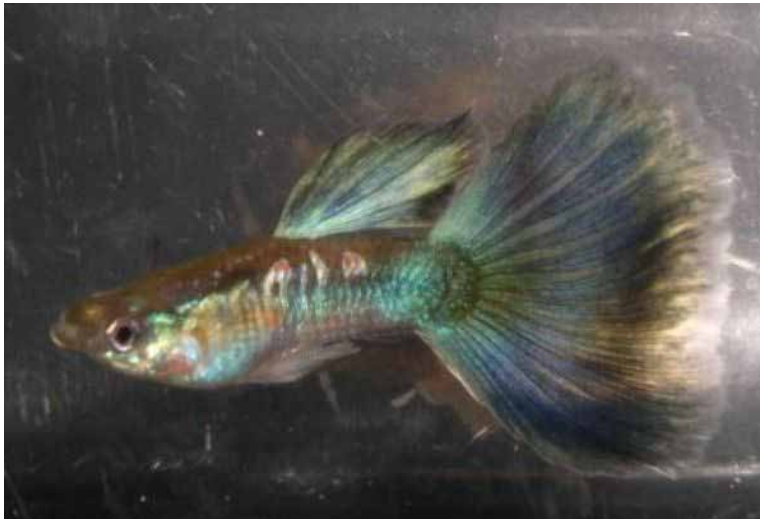
This strain is descended from stock shown in the Doublesword VEG entry. It was the result of a cross between a Doublesword VEG male a female Schimmelpfennig Platinum Sword. The entire F1 drop had males with a single bottom sword, despite the fact both parents were doubleswords.

You can see from the picture above that this guppy has the same Emerald Green Iridescent gene as the Vienna Emerald guppy. It also shares the overall metallic blue color of the Doublesword VEG father.

Old Fashioned

According to Yasube, a Japanese member of the Guppy Designer forum, it is common knowledge in Japan that the strain got its name from a guppy shop staff member who liked the old rock group Three Dog Night song called, "An Old Fashioned Love Song."

A cross between a Vienna Emerald Green and an IFGA Green. Philip Shaddock



Old-Fashioned Blue Tail from Tomoko Young's fish room. Tomoko acquired the strain from Bruce (Hsueh Tseng-Biao) in Taiwan. The strain comes from Japan.

This is basically a Vienna Emerald Green phenotype with a delta tail instead of a swordtail.

The version show above has the blue tail gene, but the strain is more commonly seen with a mosaic caudal fin. Tomoko's strain has a delicate beauty somewhat lacking in the "traditional" Old-Fashioned strain, which is much closer to the Viennese Emerald Green in pattern. Doubtlessly the reason this strain is called "old-fashioned" is because the more typical pattern is closer to the wild guppy in its polychromatic variability than most modern strains.

Genetics

The blue tail gene can be X- or Y-linked. You can create a version of this strain by crossing a Viennese Emerald Green double sword to a delta tail. As Tomoko's version shows, there is a lot of scope for experimentation.

The probability that the strain is descended from the Viennese Emerald Green Double sword is confirmed in a publication called the AF-Japan book. A visual inspection of the two guppies adds additional proof.

The interesting question is whether or not it has the Cp (*Pigmentierte caudalis*) gene to fill in the areas between the swords, or whether it just has the fin elongation genes to make it a delta tail.

Top Yellow Sword 2004 Endler

Top Yellow Sword Endler. Picture by Karen Koomans.

The Endler is also called the Campona guppy.

This original type of Poecilia wingei was found in 2004 by Armando Pou Endler at Black Pond on the east side of the Autopista Jose Antonio River, south of the Laguna la Malaguena (Venezuela). This line is bred by Adrian HD (USA). It is one of the many strains registered with the ERU (Endler R Us) Classification System (ECS). The ECS strain number is N-05-0021 (see [Endlers R Us]). '2004 Top Yellow Sword is another name for the same strain.

Typical of the "2004 Top Yellow Sword" phenotype are:

- A yellow upper sword;
- An orange spot at the tail base;
- A black sport on the lower middle part of the body.
- Note that there is not a typical Endler sword extension to the caudal fin. It has colored edges and an otherwise colorless caudal fin.
- The body is very colorful.

Genetics

The above described characteristics of this strain are dominant and Y-linked. If you have good founding stock, they inherit the characteristics as seen on the accompanying photos. If fish are born without the correct traits, they should be culled right away, to maintain the visual traits of the strain. Of course you can change the look of the strain by outcrossing, or by selecting mutants that are born from pure stock. But these offspring are not considered to be a N-class Endler, according to the standard. You are then breeding class P or K-class Endlers, what can be fun, but it is no longer considered to be the authentic 2004 Top Yellow Sword stain.

Breeders Comments

Karen Koomans

I recommend this authentic Endler strain, with its glittering bright colors and interesting behavior. Please note that these fish need to be isolated from other strains. If you master this particular breed and want to maintain it, you should acquire your first stock from a "registered breeder." This is the only way to make sure that you will get an N-class animal. A list of registered breeders can be found on Endler R Us, under the forum topic 'ERU Strain Registry - List of Registered strains'.

Tangerine Guppy

According to Junichi Ito, the Tangerine guppy combines the magenta gene with the Endler. This is what gives the strain its distinctive tangerine color. A guppy (*poecilia reticulata*) combined with the magenta gene gives the guppy a magenta color.

Tangerine guppy. Photo by Junichi Ito

Junichi provides a close up of the color. Notice the yellow color.

The fact that the Endler with the magenta gene is a different color than the guppy with the Endler gene is interesting. It means that the Endler must have different color cells than the guppy, or there is a difference in the way the color cells are regulated. The Endler is known to have much more intense color, which suggests that the difference must be in the way color is regulated.

White Tangerine

White Tangerine. Guppy and picture by Junichi Ito

Junichi told me that the Tangerine Endlers sometimes throw a white version, as in the picture above.

Balloon Guppy

Balloon Male. Philip Shaddock

Balloon Female. Philip Shaddock

Other names for this guppy are Bubble Guppy or Short Guppy.

This is a guppy that appeared in a cross I did between a Half-Black Yellow male and a Thai Midnight Black Moscow. The two "balloon guppy" individuals appeared in the F2 generation.

This is not so much a strain of guppies as a developmental anomaly. The guppy's length is dramatically shortened by a deformed spinal chord, where the vertebrae are apparently fused.

In the pet trade there is a type of Molly called a "Balloon Molly," hence the name for this type of guppy.

The Balloon guppy makes its appearance in the hobby occasionally, then disappears. There is apparently too many "beautiful" mutations available to the hobbyist to make this mutation attractive.

Genetics

The Breden Lab at SFU, which does scoliosis research, is studying this particular pair and its descendants.

The Aquarium Wiki has an interesting article that sheds some light on this type of guppy.

> Balloon is a generic term used to describe various fish species (usually freshwater species) which through careful selection to enhance and stabilise a genetic deformity that makes the overall fish body much shorter and rounder in shape, hence the name.
>
> This is done as the fish shape is pleasing to people. Side effects are that the animal will be slower in swimming and tend to have swim bladder problems (infections and less ability to adjust its height in the water column). It often tends to have digestive problems as the stomach and intestines are distorted within

the body making it more difficult for it to digest normal foods. These types of fish tend to need a special gel like diet to aid digestion as they get easily constipated.

Some balloon fish may have difficulty in mating naturally and often only breed by human intervention.

The aquarium environment needs to be designed to allow the fish ample room to turn and to remove any sharp objects it may bang against due to its lack of manoeuvrability.

Included in the wiki entry is a picture of a "balloon" goldfish.

Crown Pearlscale Goldfish

The fact that the molly and goldfish breeders are able to selectively breed for this trait suggests the deformity is genetic and inheritable.

Breeding of this particular strain is difficult. Look closely at the male's gonopodium and you will see it is also deformed. The female will have to be impregnated by one of her normally shaped brothers. It is most likely an autosomal recessive condition, so balloon gup-

pies will appear at a ratio of 1:4 in the F2 generation. I have read one report that the trait is dominant, but I am not sure of its validity.

A Appendix: Gene Symbols

Many of the entries in the Guppy Color Bank include formulas (genotypes) that show the genes that participate in the networks that generate guppy color and patterns and where the genes are located. This section will help you interpret the formulas.

Autosomal Notation

Gene symbols look like this:

aa

The letter "a" is the first letter of the name of the mutation (albino in this case). It is shown as two letters because guppies have two sets of chromosomes and therefore two alleles.

The wild type form of the gene is indicated by capital letters:

AA or A/-

The capitalized version of the gene symbol indicates it is dominant.

Since a dominant allele is expressed at the expense of a recessive allele, a pairing of a dominant allele with a recessive allele is functionally equivalent to a pairing of two dominant alleles. This is indicated with a capitalized letter followed by a forward slash and dash (e.g. A/-).

Where you do want to show a paired dominant allele with a recessive allele, this is the notation:

Aa

The **phenotype** of the hybrid guppy would be grey, and the **genotype** would be ***Aa***.

Sex-Linked Notation

Unlike the case of the autosomal genes, genes on the sex chromosomes only require one of the genes to be indicated. A gene on an X and Y chromosomes is represented as (using the Moscow mutation as an example):

$$XY^{Mw}$$

This indicates the guppy has the Moscow (Mw) gene on the Y chromosome. The gene symbol is capitalized to indicate it is dominant over its wild-type allele.

Because genes can cross over to the opposite chromosome during sexual reproduction, the genotype shows the most common location of the gene.

B Appendix: Gene Table

	Symbol	Location
Sex-Linked Body Colors		
Bcp (Black Caudal Peduncle)	Bcp	XY
Blue Diamond or Luster	Bd	XY
Coral Red (Neon in Europe)	Co	Y
Emerald Green Iridescent	SmIr	Y
Japan Blue (Aquamarine in Asia)	A	XY
Moscow	Mw	Y
Half-Black (Nigrocaudatus Ni)	Ni or NiII	XY
Half-Tuxedo (Saddleback)	Ht	XY
Pink White	Pw	XY
Schimmelpfennig Platinum	Sc	XY
Snakeskin body	Ssb	XY
Turqoise	T	Y
Viridis	Vir	Y
White Saddle	Ws	XY
Autosomal Body Colors		
Albino (RREA - Real Red Eye Albino)	a	autosomal
Bar	bar	autosomal
Asian Blau	Ab	autosomal
Blond (Gold in the U.S. and Asia)	b	autosomal
Glass Belly	gb	autosomal
Golden (Gold Europe, Bronze U.S., Tiger Asia)	g	autosomal
Magenta	M	autosomal
Metallic gold	Mg	autosomal
Midnight Black	mid	autosomal

Onyx	on	autosomal
Pink / Pingu	pk	autosomal
Solid (Micariff)	So	autosomal
Störzbach Metal	s	autosomal
Zebrinus	Ze	autosomal
Fin Shape		
Elongated Dorsal or Hi-Fin	Eld	autosomal
Fantail	Fa	X
Pintail / Needletail	Pt	X
Ribbon / Giessen	Rib	autosomal
Roundtail	Rndt	XY
Spadetail	Spt	XY
Speartail	Sp	X
Suppressor	Sup	autosomal
Swallow	kal	autosomal
Double Sword	Ds	Ds
Fin Color and Pattern		
Black Tail	Bt	XY
Blue Tail	Blt	XY
Flavus	Fla	XY
Grass	Gra	XY
Green Tail	Grt	XY
Merah (Crowntail)	Me	autosomal
Mosaic	Mo	XY
Pigmentierte caudalis (Cp)	Cp	XY
Red Tail	Rdt	XY
Snakeskin Tail Pattern	Sst	XY
Platinum Tail (White or Yellow)	Plt	XY