Breeding Guppies: Genetic Pitfalls and Successes
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Most fish keepers view guppies as children’s fish. However, if ever there was a fish to study livestock breeding and genetics, it is the guppy *Poecilia reticulata*. Learning more about the genetics of the strains I work with has definitely increased the success of breeding projects. As I show in this article, I wasted a lot of time raising batches that were genetically predestined for disappointment. Twenty, thirty years ago there was not much genetic information available. Now, there is plenty [1, 2, 3, 4].

**My Experiences**

I have kept guppies off and on since childhood. In 1988, I created my own blue delta strain [Fig 1] by crossing a store-bought male with a female from a breeder’s strain with dark blue delta tails. The male had less impressive finnage but sported beautiful, iridescent sky-blue colors. The resulting progeny (F1) combined the best of both parents. During the two years that I kept these guppies, I simply removed any inferior fish or orange-colored males.

Later in 2017, when I ventured more seriously into breeding guppies, I found myself inadvertently stumbling into several genetic pitfalls.

First jolt came with the Swallowtail strain. The breeder sent me 5 juveniles. The males turned out nice, but afterwards the breeder explained that the strain carried a gene that made it impossible for some of the males to breed. The ones with the ribbon-like finnage [Fig 2a] had a long gonopodium that could not impregnate females. Apparently, males of the strain without this abnormal fin/sex organ were the ones that breeders used to keep the strain going. Still, my breeding this strain would be complicated. I would have to choose males for a functioning male organ as well as color, vigor, size, etc. And if I bred Swallowtail females to another strain, would I have the same

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1 This article represents a continuation of my 2017 article ‘Small Scale Guppy Breeding’.
2 Guppy strains with these fins contain one or more fin elongation genes (Kal, #171; Sup, #170; or Rib, #163). {Numbers used here (and throughout this article) correspond to genotypes listed in a gene reference table [3].}
problem? The owner chided me to read up more before I bought fish. Good point, but alas, I never suspected that anyone would breed guppies where the males could not impregnate the females.

Sadly, I concluded that the Swallowtails were a dead end, at least for me, and discarded them. Later, I learned that it wasn’t just Swallowtails that carried fin elongation genes [Fig 2b].

A subtler genetic pitfall was the disappointing results from the Metalheads. The males were gorgeous, but I got only 1 or 2 beauties out of a batch; the rest were just plain ugly.

Crossing Metalhead males with BG (Blue Grass) females did not improve matters [Fig 3]. Breeding Metalheads was getting too complicated. How does one select breeding females from a batch where the majority of males are unacceptable?

At the time, I was not sure whether the problem originated from the BG or the Metalhead strain.

However, the genetic puzzle became a moot point when the two Metalhead males sickened and died. Their disease susceptibility was the last straw. The Metalheads that I purchased were advertised as rare. I can understand why.

While my BG strain was less disease-susceptible, they produced only about 30% BG males. I was getting a mix of BG, Red Grass, and BT culls.  (More on this later.)

In response to this disappointing non-uniformity in progeny, I turned next to guppies from the pet shops. For I assumed that commercial guppy breeders in Southeast Asia were not going to keep strains that produced only 2-30% saleable fish.

![Fig 2b Another Handicapped Male](image)

Apparently, genes for fin elongation were incorporated into this particular BG (Blue Grass) strain.

![Fig 3 Outcrossing Metalheads with BG](image)

This Breeding Group of beautiful guppies that I had raised myself was designed to produce beautiful babies.

Unfortunately, most (~95%) of the F1 were small and unattractive like the male on the left. I call them BTs (Black Tails). Males that will develop the beautiful Metalhead phenotype like his sibling on the right were few and far between. (Photographed at 5 weeks of age)
I tried working with HB Blues (Half-black Blues), a popular commercial strain, sometimes called Neon Blues and frequently available in stores. The strain has an iridescent white/blue top that makes it an interesting fish when viewed from above and for ponds. However, it did not have the nice finnage and light blue iridescent color of my BG strain. Perhaps crossing it with BG females would improve the strain while keeping its unique iridescent blue top?

Earlier, I complained about the lack of uniformity in BG and Metalhead progeny. However, with the HB Blue X BG cross, I got wholesale uniformity [Fig 4] and found it disappointing. Not one of the F1s showed the pretty grass pattern tail of my BG. Apparently, the HB Blues carry dominant genes that over-rode those of the BG strain. The HB coloration showed up on all fry at birth—males and females. I have never been a fan of Half-Black guppies, and this experience cemented my prejudice.

The F2 was no better. This uniformity was boring; I might just as well have been breeding Tetras or Gouramis where the progeny all looked alike and just like the parents. Their shiny blue tops didn’t make up for the solid dull colors elsewhere and their smallish dorsal fins. So I dispensed with the HB Blues.

The BG (Blue Grass) strain [Fig 5] turned out to be my most satisfying strain. It is beautiful, docile, and relatively hardy.

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3 The basic genotype of the HB Blue strain is Asian Neon (#63) featuring the co-expression of genes NiII and Leucophore White. Asian Blau (Ab), #69 is sometimes added to suppress orange pigment. Black caudal peduncle (Bcp, #65), a dominant genes carried on both X and Y chromosomes, codes for the HB trait. [3].
The blue color of most BG strains is due to Ab (Asian Blau), a partially dominant gene on the autosomes (i.e., non-sex chromosomes). Ab suppresses red and yellow colors to produce an iridescent blue color over the entire body. Depending on how the Ab gene sorts out during meiosis, the progeny of a BG mating will be a mixture of BG, Red Grass and BTs (“black tails”) [Fig 6]. BTs are small, weak, light-grey guppies with tiny black tails.

All BG guppies still carry genes for orange and red pigments, but they are suppressed by Ab. In the Red Grass where Ab is absent, these color genes are allowed full expression.

With my BG breeders, I get about 30% nice BG males in a batch. Most breeders cull the BTs. The Red Grass [Fig 7] differ only from the BG phenotype in that they are not blue. The Red Grass is every bit as beautiful as the blue form. The bonus in breeding BG guppies is that the strain produces not one but two desirable phenotypes.

Moreover, BG are genetically pliable. Its genetic architecture “plays nice” with the genes of other strains. Upon outcrossing, it does not totally dominate like the HB Blues, where 99% the progeny looks like the parents. The BG strain contains a mixture of dominant and recessive genes that upon outcrossing produce new and exciting phenotypes.

4 My BG strain carries genes for: Delta Tail, #146; Hi-fin Dorsal, #158; Ab (Asian Blau), #69; Variegation (produces grass pattern), #141; and Pb (purple body), #227 [3]. Not all BG strains carry the Pb gene.
For example, I crossed a BG male with a yellow female from the pet shop [Fig 8]. Most of the fry were rather ordinary, but I got two attractive cobra males that I hoped to propagate. So I mated the male to one of his siblings.

Unfortunately, the F2 from mating F1 siblings produced males with yellow and pink solid coloring and white bellies [Fig 9]. These phenotypes represented the homozygous expression of recessive genes\(^5\) from their pet shop granddam. Not one of the F2 had the desired body and tail pattern of their cobra sire. I decided not to pursue breeding these guppies. If I wanted to breed cobra guppies, it would be better to simply purchase a cobra guppy strain of known genotype. No need to re-invent the wheel…

\(^5\) Most of the progeny had white bellies, some with a pink stripe above the lateral line, an expression of the Micariff White gene (Mcw, #99) [3].
Outcrosses with Swordtail Guppies

In 2017 and on a whim, I purchased two swordtail males from a pet store. They were double swords (Ds), advertised simply as lyretails. However, I recognized the iridescent blue body color, which is characteristic of the JBs (Japan Blues). Wild guppies with the JB phenotype were first discovered in the late 1980s in a Japanese river. They have a beautiful, iridescent blue peduncle. My two males had a white/purple double sword, but the fins of Japan Blues can be any color or shape.

When I crossed the JB males with one of my BG females, the resulting progeny (F1s) were uniformly fast-growing, vigorous, and absolutely lovely [Figs 10 and 11]. All the males had the iridescent blue bodies of their sire plus the big delta tail and grass pattern of their BG dam. As juveniles, some males had a “caudal gap,” suggesting that they might be double swords, but by adulthood they had all developed delta tails.

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Fig 10 Outcross between JB Male and BG Female

The sire, a JB (Japan Blue) Double sword (Ds) carries the gene for his unique blue body color. (Unfortunately, the lighting that I used for this photo gave his body color a purplish hue.)

BG dam used for the outcross.

The progeny had the JB body color of their sire and the delta/grass tails of their BG dam.

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6 The Ca (Caeruleus, #74) gene is expressed in males as a heavy density of blue reflective cells (iridophores) AND the absence of red and yellow pigment cells on the body [3]. The Ca gene responsible is dominant and carried on the male’s Y-chromosome, so it is only passed from males to their sons.
Fig 12 shows how the two tail genotypes sorted out from this mating. Genes for the delta tail (Dt) of the BG female dominated the recessive gene for the double sword (Ds). Thus, all males had delta tails.

To confirm that the F1s were actually carrying the recessive Ds gene, I allowed some F1 siblings to mate and raised a batch of F2 progeny. About half of the F2 males had double swords like their JB grandsire [Fig 13]. The F2 swordtails are due to recessive Ds genes coming from both F1 parents and pairing up together on a chromosome [Fig 14]. This homozygous expression of recessive genes in the F2 is classic Mendelian inheritance.

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7 Genes for the double sword (Ds, #147) are on the X and Y chromosomes. Delta tails (#146) are a trait resulting from a combination of Pigmentierte Caudalis (Cp, #138), and ironically, the double sword gene (Ds, #147) [3].
The results with the Japan Blue swordtails were so stunning that I repeated it with swordtail guppies (Ls or Lower swords) purchased from a recognized and long-term breeder [5]. The Ls guppies carried genes for iridescent colors that I was interested in. Moreover, swordtails have a reputation for “fitness factors” (i.e., longevity, fertility, growth rate, etc).

One Ls male [Fig 15] turned out to be a wonderful sire when crossed with a BG female. All the F1 males were absolutely stunning [Fig 16]. They displayed brilliant iridescent colors inherited from their sire and the grass/delta tails inherited from their BG dam. I kept two for breeding [Fig 17].

Progeny from reverse crosses (mating BG males to an Ls female) produced swordtails and small, less impressive offspring. Thus, I did not pursue the outcrossing of Ls swordtail females.

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Fig 15  My Ls Male Guppy carries a boatload of iridescent color genes, many masked here by the blue color from the Stoerzbach gene.

Fig 16  F1 (Ls X BG) Males were not exactly uniform in color and pattern, but in my opinion, they were uniformly pretty.

Fig 17  F1 (Ls X BG) Males that I kept for breeding. The green patch at the base of the caudal is from their Ls sire’s Emerald Green Iridescent (EGI) gene.

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8 My Bias Ls male carries genes for yellow color [Metal Gold (Mg), #96]; blue color [Stoerzbach (me), #97 and Asian Blau (Ab), #69]; green color [Vienna Emerald Green (VEG), #124 and Emerald Green Iridescent (EGI), #78]; and vertical stripes [Zebrinus (Ze), #249]. Genes for the Lower swordtail (Ls, #145) are on X and Y chromosomes [3].
Breeding the F1s

Because I wanted delta tails—not swordtails—I next had to breed out the swordtail genes. Based on preliminary work with the JBs, I knew that breeding F1 siblings would produce an F2 mix of swords and deltas.

The recommended method to keep and re-enforce the delta tail genotype is a backcross, but it should be with F1 males to delta-strain females. A comparison of Punnett squares shows why. **Fig 18** shows that half of the females and half of the males will carry the Ls gene. Any F2 females carrying the Ls gene can create problems down the road. For example, one cannot mate that female to any males carrying the Ls gene on their Y chromosome without getting Ls homozygotes and the lower swordtail phenotype. Options become limited.

**Fig 19** shows a better pathway. None of the F2 female progeny have Ls genes. I also did not want to lose the iridescent green patch of my F1 males. (I was not sure that the F1 females carried the EGI gene.)

So I paired the reddish F1 (Ls X BG) male (Fig 17) to a BG female and saved as many of her progeny as possible. She produced 3 beautiful male phenotypes (**Figs 20**-**22**). Amazingly, this included the BG and Red Grass that had been absent in the F1. The red-green males in Fig 21 are more like their sire.

Discussion

In this article, I have described a few pitfalls I encountered in breeding guppies. I quickly learned that a basic understanding of guppy genetics could save a lot of time, money, and effort. The deceptively simple Punnett square became an invaluable tool.

It makes a big difference which strain to use as the sire in an outcross. For example, because the gene for the Japan Blue (JB) color is on the Y-chromosome, I did not waste time breeding a male BG to a female JB. In general and in nature, the male’s Y-chromosome carries the color genes, so when in doubt I will use the male for bringing color into the progeny. The opposite situation (e.g., BG guppies carrying the Ab gene on the autosomes of both sexes) is less common.

I would ask readers not to judge highly bred strains (Metalheads, BG, etc) on my limited experience. Other hobbyists may do well with Metalheads and not so well with BG. Many strains have “sub-strains” whose quality can vary depending on the breeder. Quality can diminish rapidly by random inbreeding or unfortunate choices of breeding stock. Moreover, accidents and disease can wipe out prime breeding stock leaving only a small population of less desirable individuals to work with.
I used outcrosses to create colorful guppies, increase fish fitness, and learn more about guppy genetics. Outcrosses produced beautiful F1 hybrids, but I did not declare victory until the F2 generation. For it is in the F2, especially with inbreeding (backcrosses and sibling matings), where recessive genes would be expressed. The F2s shown on this page are far better than I ever expected. I obtained not one but three beautiful phenotypes to work with.

Fig 20  F2 Blue Grass (4-5 months old).


Fig 21  F2 Red/Green Guppies
Notice how the green color from the EGI gene has migrated into the tail itself.

Fig 21  F2 Red Grass-Type Guppies

REFERENCES