Gouldian Finch Genetics In Color Mutations
and how they affect pigment synthesis.

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To see photos of Gouldian colors such as red headed, black headed, yellow bodied, white breast and a blue dilute Gouldian please link to

http://birdpets.onenessbecomesus.com/Genetics.html

Lady Gouldian finches, in spite of their extraordinary color scheme, produce all colors from the same five basic building blocks as seen in many species of birds. Red, yellow, reddish-brown, or black are chemically derived or absorbed pigmented colors while blue is a structural color. Blue is seen as the result of wavelengths from the red end of the color spectrum being absorbed by modified feather barbs leaving blue to be reflected back.

The four pigmented color descriptions are designated as

I. two Carotenoids:
   1. Lutein: a yellow pigment absorbed from food.
   2. astaxantin: a red pigment made from lutein.

II.Two Melanins:
   1. Phaeomelanin: for Reddish to Brown pigmentation.
   2. Eumelanin: for Black pigmentation.

Here are the three common;
Red-head, Black-head and Yellow-head
colors found in the Gouldian finch.

Let's take a look at what will probably be your first experience in the realm of color in Gouldian finches, namely, the Black headed, Red-headed and Yellow-headed varieties. Black and Red-headeds represent the commonest color forms seen in the wild and in captivity while Yellow-head is seen rarely in the wild. Ornithologists once considered them to be seperate subspecies but Black, Red and Yellow-headed varieties interbreed freely showing consistent genetic patterns of inheritance. Red-headed is sex-linked dominant over Black-head while Yellow-head is autosomal recessive to both. What is of interest here is the interelationship between the three head

colors. Black is independent from Red and Yellow-headed. The color black is a component of melanin which involves a different mechanism for color production than the red and yellow carotenoid forms seen in either Red or Yellow-head. Therefore the two color processess, or inability to synthesize the processess, is inherited independently. This explains why a black headed Gouldian can have either a red or yellow tipped beak. Red tipped beaks show the bird has the ability to synthesize red. Cocks of this variety cannot mask or carry Red-head because it is dominant. Conversely, it is possible for a male Red-head to carry and mask one Black-headed factor. Hens can have only one sex-linked factor for either Black or Red-head but can carry the autosomal recessive Yellow-head just like the cocks. Yellow tip beaked black-heads are unable to make red so the beak remains yellow. Therefore yellow tipped beaks are proof that these birds actually are carrying two factors for Yellow-head which would be seen except for the masking properties of the black head. Yellow tipped Black-heads are truly Yellow-heads underneath the black.

Now let's continue and take a look at some domestically introduced mutations, how they are produced, and combination results. For our purposes the term "bodied" on a mutation refers to the whole body of the bird excluding the head and breast colors. As will be increasing evident, as in the head types already noted, the head and breast colors are more or less independent of the "bodied" colors.

In normal colored birds all colors are being properly synthesized and are displayed as seen in the wild. A mutation, or combination of mutations, usually represents varying degrees of inability to manufacture or display, all or in part, one or more of these building blocks of color. The mutation effect may be limited to one, all, or any regions of the body. Domestic bred mutations are generally restricted to altering what the normal bird has in its makeup. To create a whole new component is exceedingly rare. A success here requires a species evolutionary time scale of millions of years.

Here is an outline looking at what happens when one or more of the four normal color components (see beginning) are missing in the various domestic mutations of the Gouldian finch.

I. Control group:

All four color groups are synthesized properly.

Normal wild colors = Black-head, Purple-breast, green back, etc.

II. Lacking only eumelanin or black pigment:

A. Red-headed - sex-linked dominant: Can be seen on all birds able to display both, either or no melanin colors on the remainder of the body.

B. Dilute-bodied - sex-linked partial dominant. dilutes show no black but have all other colors. (Only single factor cocks can show dilute. All others with this mutation are Yellow-bodied and cannot process any melanin at all.)

C. Lilac or Rose-breasted - recessive to Purple-breast but dominant over White-breasted.

III. Lacking only phaeomelanin or reddish to brown pigment.

A. Blue-breasted - recessive and dominant forms?

IV. Lacking only astaxantin carotenoid red pigment: (Manufactured from lutein.)

A. Yellow-headed - recessive (This mutation can be masked by Black-head but the inability to make red in the body is evident by a yellow tipped beak.)

V. Lacking only lutein carotenoid yellow pigment:

Since lutein is the source for astaxantin red any bird lacking lutein absorbtion obviously cannot synthesize astaxantin from it. A carotenoid based all red bird without the yellow luteun base is therefore impossible. Since the two colors, yellow and red, are missing I have placed mutations fitting this category (showing no carotenoid colors) under the "Deletion of two or more colors".

Here are some results when two or more colors are deleted from a Gouldian finch.

A. Yellow-bodied: Both dark colored melanin groups cannot be processed. Green color is erased due to a masking of the structural blue. The result is a brightly colored yellow bodied bird.(Yellow-bodys can be mixed with any breast color such as purple or any carotenoid produced head color. Black-head is reduced to a very pale whitish gray.)

B. White-breasted - recessive: Both melanin groups cannot be expressed. (White-breast can occur on any body color of Gouldian.)

C. Blue-bodied - recessive: Both carotenoid (red and yellow) colors are absent creating a blue background colored bird by default. (Blue is reflected by feather structure - not made by food synthesis.) Again, all breast colors are seen on these blue birds.

D. Silver-bodied or Platinum is the next process of combining Blue-bodied with Yellow-bodied. Silver Gouldians, like Yellow-bodys, are unable to manufacture any of the dark melanistic colors. In addition, The Platinum cannot produce carotenoid red and yellow either. This leaves us with a blue bird that has a problem. The Yellow-body factor prevents even the blue from showing up. The end result is a rather dull silvery looking bird. The final act requires the deletion of any color yet seen in the Purple, Rose, or Blue-breast. This is done by adding White-breast to the Silver. Now virtually all color is missing on what in nature vies as one of the most colorful birds on Earth!

In performing this little exercise I came up initially with a few fascinating results.

A. Breast colors appear to be inherited independently from body colors. All body colors can be mixed with any of the breast colors. Additionally, all breast colors seemingly lack all carotenoid color. Purple, rose, blue, and white breasted mutations are respectively symptomatic of synthesizing both melanins, a lack of eumelanin only, a lack of phaeomelanin only, or being unable to produce any melanin color at all. Nowhere in breast color is there the red or yellow seen in carotenoid color.

B. Head colors seem to be partially independent from body color. Black, Red and Yellow heads all show up on normal bodied birds (all normal birds by definition can produce all component colors) but this does not hold true for birds displaying body color loss-mutations. Red or yellow head, being carotenoid produced, show up nicely on a Dilute-body or Yellow-body where Black-head is muted. Conversely, Red-head or Yellow-head is muted,

showing only the melanin colors on a Blue-body while a black color, including Black-headed, shows up fine.

C. It is well known the Dilute/Yellow-body allele is directly influenced by the White-breasted gene. Any genetically single factor Dilute cock showing a visual White-breast is enhanced to look like a double-factored Yellow-body. That is not all!

D. Rose-breasted also appears to share an affinity with White-breast. occasionally, Rose-breasted appears to pop up out of nowhere when split White-breast is bred to another split or visual White-breast. The Rose-breast is closely akin to the Dilute - neither can process the black eumelanin color. Also, White-breast shares the same relationship with Yellow-body - neither can process either of the dark melanin colors. Is there some sort of crossover between breast and the body color inheritence going on?

Here are a few personal questions regarding red and blackheadedness that I have no real answers for. This is partly what makes the science of aviculture so much fun!

Red-headed and Blackheaded mutations are commonly found in the wild with black heads outnunbering red heads by three to one. Yet, as alluded to before, both colors show consistent genetic inheritance patterns with Red being sex-linked dominant making Black-head a sex-linked recessive.

Questions: which one is the true mutation? Why are red headed wild populations in the minority?

What happens if we flip the coin and assign Black-head as the recessive sex-linked player, which is a much more frequent pattern, and assume for the moment that Red-head is the normal color. Black-head would then qualify as a highly succesful mutation for this color usually is the hardiest and most prolific Gouldian around. Maybe black headedness is the wave of the future for wild populations; who knows.

In addition there exists a denser rich feather barb structure witnessed in black headed Goulds that may be an important modifying agent for the production of black eumelanin. This could help explain why female red heads have such a variable amount of red. Occassionally young hens may

fool you by looking much like a black head but during subsequent molts and breeding results come out as red.

Potential problems arise when assigning Red-headedness as normal and Black-head as a mutation. When these observations are added up the case for Black-head being the true normal form is quite strong.

1. Not many mutations are sex-linked dominant as exhibited by the Red-head allele. Most are a recessive form.

2. Also, black heads are most often the strongest birds which is contradictory to most mutations being a liability to virility. As a rule a new mutation must be carefully bred in to assure it is not lost.At the same time the breeder must ruthlessly strive for increased stamina in birds carrying the desired trait.

3. Of great interest is the question of where those more numerous additionally dense feather barbs indicative of Black-headness come from. It is so rare for a mutation to add any element to the make up that the head feather barb structure differences between red and black headed Gouldians in itself presents a strong case for Black-head being normal.

4. Last but certainly not least is the fact that red headed Goulds lack the eumelanin black found in black headed specimems. This is the reason I assigned Red-head as one of the mutations.

In applying the above criteria based on common experiences with domestic loss-mutations we must remember that the red-head and black-head varietys are both found in the wild. There is no way of knowing just how ancient either of these colors in the wild are. Maybe none of the above questions really apply or if they do it may be in ways we don't understand.

Color physics can be seen as well. Here are a few examples.
A.Normal Gouldians show green where the blue on a Blue-bodied Gouldian would be. This is because the normal yellow carotenoid pigment mixes with the refracted color blue to produce green.

B. Purple breasted, a normal color, is brought about by the reddish-brown phaeomelanin modifying the structural blue effect and producing a light reddish purple such as found in the Rose-breasted mutation. The addition of black eumelanin deepens the rose bringing about the normal deep purple.

C. In white or Silver birds (Blue-body/Yellow-body) the broad spectrum of the white light reflecting from the feathers obliterates the blue color but the feather barb structure responsible for blue color under normal circumstances are still present.

In closing it must be said that the color pallette and genetic properties displayed within the tiny jewel-like Lady Gouldian finch make this a rich biological heritage for the Aviculturist and hobby-pet owner to enjoy. Gouldians are not faring well in the wild. Within the last thirty years numbers have drastically dropped. Let us remember this fact and become real caretakers of this special species.