Mehnoor and Nia's Science Fair Project 2023-2024

<u>Friday November 24, 2023</u>
We decided on our science fair topic. We chose this to be our topic because we're both interested in the controversy over the ethics of breeding ball pythons with the spider morph. Nia also owns two ball pythons so she brought up the idea of doing something related to ball pythons.

<u>Thursday December 28, 2023</u>
We wrote down our ideas and questions for some of the related topics. All the questions we wrote today was:
"What are Snake Morphs?"
"How do they alter the colour and/or pattern of a snake (as seen in ball pythons)?"
"What is the difference between dominant, codominant, and recessive?"
"How can they alter the behaviour of the snake (as seen in ball pythons)?

We were also thinking of some questions like:
- Do some morphs have a higher or lower chance of being pasted on to the offspring?
- Can any morphs affect the overall body shape of the ball python?
- How can morph alter the personality of the snake (as seen in ball pythons)?

But after doing some research we couldn't find any information about any of these happening, so we decided to not try to answer them.

<u>Wednesday January 10, 2023</u>
Today we discussed and wrote down the definitions for the terms that we would use in the project including:
- Allele = Its locations are in the same place on a chromosome and it's one of two or more variant genes that are different. They result from a mutation as well.
- Heterozygous = carrying one allele from each parent & the alleles are different from one another
- Homozygous = carrying two identical alleles (some morphs requiring both alleles to show trait whereas others need one)
- Morph = a mutation in the snake's genetics that cause patterns on the snake to change
- Dominant = for a snake to have a morph, it needs only one allele carrying that genetic trait
- Co-dominant = snake needs only one copy of the gene to have a morph & show the trait (heterozygous)
- Recessive = the snake needs to have both copies of gene to show any pattern change visible to the eye

We also added the links to the websites we got the information from and we included examples with each term to help people further understand the words.

<u>Thursday January 11, 2023</u>

We colour coded the information we had and added onto our information specifically more terms and examples of the types of ball pythons
- **Chromatophores** = cells producing pigments in the colour, pattern, etc of a snake & there are three types of chromatophores
- **Melanophores** = cells producing black/brown pigments
- **Xanthophores** = cells producing yellow/red pigments
- **Iridophores** = cells reflecting light - they appear iridescent, green, blue, gold or silver

The examples of most common ball pythons are:

- **Normal or Wild type** - They're dominant and have dark brown with light or golden brown patterns with white accents
- **Albino/Amelanistic** - They're recessive and lack melanophores which causes them to have no brown or black pigments resulting in the snake to appear yellow, white, and/or orange with red eyes
- **Axanthic** - They're recessive and do not produce xanthophores making the snake black, dark brown or white.

We also added more questions/ideas that we could research including:
"Do some morphs have a higher or lower chance of being passed onto offspring?"
"Can any morphs affect the overall body shape of a ball python?"

<u>January 16, 2024</u>
Added only one more question/idea we could research; "Do some genes increase the chance of twin baby snakes?" Though after some searching it does not appear to have occurred, nor has anyone else seemed to have even thought about it.

<u>January 23, 2024</u>
Added onto more of the most common ball python types:
- Piebald (and Paradox)
- Spider
- Mojave

We added one more source we could use to research more about the different kinds of ball pythons and morphs
After we tried researching some of the questions we thought of, we realized that there were no reports or any information about the topics and decided to remove them from the project. The questions were: "Do some genes increase the chance of twin baby snakes?" "Do some morphs have a higher or lower chance of being pasted on to the offspring?" "Can any morphs affect the overall body shape of the ball python?" "How can morph alter the personality of the snake (as seen in ball pythons)?"

<u>January 29, 2024</u>
We made a list of all the materials we would need for science fair including:
- A trifold
- Printer
- Paper (blank and various colours)
- Pictures of snakes

- Genetic graphs (showing how the different genes act with each other)

We also decided on who would get what materials

We started working on the genetic anomalies that the morphs can come with

- ❖ Spider (+ any snake having spider gene) - known to have a head wobble that can affect eating, drinking and general mobility
- ❖ Desert - females aren't able to reproduce
- ❖ Super Cinnamon - can have eye defects including "bug eyes" where the eyes are very large, very small eyes or a combination of both. They can also have kinking where the spine has a deformity. Most kinks aren't life threatening but it can be depending on where the kink is on the spine. Extremities can go from the tail being turned upwards to the entire stomach of the snake being misplaced.
- ❖ Spotnose x Champagne - they can also have the head wobble causing them to shake their heads or lay in strange positions
- ❖ Super Black Pastel - can also have very large "bug eyes," very small eyes or a combination of both. In some cases, "no eyes" can occur to the snake due to an issue with the incubation such as it being far too hot or too many temperature fluctuations being present. However, lack of eyesight in most snakes doesn't affect them much because they rely on smell and their heat pits instead.
- ❖ Bananas - can have weird sex ratios. A female having the gene can create both male and female snakes but a male getting the gene from his mother will only be able to create female snakes as it is a gene on the X chromosome. A male that gets the gene from his father will almost always create a male snake as the gene is on the Y chromosome.
- ❖ Caramel - kinking

We also included links to the sources we got all this information on under each morph issue. We highlighted the links that led to a youtube video differently than the links that were simply websites.

February 15, 2024

We have been looking into the actual causes of the different genetic anomalies and how they are linked to specific morphs.

Nia researched and learned all about how ball python genes work and interact with each other using these four youtube videos on Clint's Reptiles Youtube channel. Biology (mainly reptile) based content created by biology major, Clint Laidlaw.

https://www.youtube.com/watch?v=0LIUbOO4o7Y&list=PLgtE7_5uJ2p5lISHOmJ1TAgEgoIGpyhXB&index=1
https://www.youtube.com/watch?v=2H5Q9eRUHCE&list=PLgtE7_5uJ2p5lISHOmJ1TAgEgoIGpyhXB&index=2
https://www.youtube.com/watch?v=kvW9MWPdFJE&list=PLgtE7_5uJ2p5lISHOmJ1TAgEgoIGpyhXB&index=3
https://www.youtube.com/watch?v=rGWRRAwKDGQ&list=PLgtE7_5uJ2p5lISHOmJ1TAgEgoIGpyhXB&index=4

The information she gathered from the videos:

Video 1-

- DNA- The instructions that determines how a person is to be
- Gene- The individual instructions that make up DNA
- Allele- The different variants of a gene
- Chromosome- The collection of genes
- Diploid- To have two copies of chromosomes (one from each parent)
- Haploid- To have one copy of a chromosome
- Meiosis- The process of splitting up chromosomes to create either a sperm or egg
- Sperm- The haploid cell that comes from the father
- Egg- The haploid cell that comes from the mother
- Zygote- When a sperm and egg join, mixing the two copies of chromosomes
- Homozygous- When having the two of the same allele
- Heterozygous- When having two different versions of a gene (different alleles)

Video 2-

- Genotype- The specific alleles that a zygote has
- Phenotype- The way the snake looks, determined by the genotype
- Dominant Allele- An allele that overpowers any other alleles in the phenotype, seen if heterozygous or homozygous
- Recessive Allele- An allele that is only seen outwardly if homozygous
- Incomplete Dominant Allele- When the alleles blend together so the look of the snake is consistent (have a “super form”)
- Codominant Alleles- When both alleles are fully expressed but show up on different parts of the body (often misused as a synonym for incomplete dominant - scaleless ball pythons might be the only true codominant ball python morph)

Videos 3 and 4-

These are matrices. It shows all of the possible combinations of morphs that the offspring could inherit from its parents.

Dominant Alleles: A (any uppercase letter)
Recessive Alleles: a (lowercase letter that is the same as the uppercase)

Example- Lesser ball python: A^L A^W (the superscript is showing which morphs are present)
This matrix is showing the possible outcomes of a lesser x lesser pairing.

Lesser x Lesser	A^L	A^W
A^L	$A^L A^L$	$A^L A^W$
A^W	$A^W A^L$	$A^W A^W$

25% Leucistic (homozygous lesser)
25% Wild Type
50% Lesser

Lesser x Pastel	A^L	A^W
A^P	$A^P A^L$	$A^P A^W$
A^W	$A^W A^L$	$A^W A^W$

25% Pastel Lesser
25% Pastel
25% Lesser
25% Wild Type

The only way to tell the genes of a ball python (without breeding and proving out the genes) is by looking at the phenotype (the way they look colour-wise)

Offspring from two heterozygous parents (of the same recessive morph) would be referred to as 66% possible heterozygous or 66% pos hets. This is because 25% of the babies would show the gene in their phenotype (homozygous recessive) 25% would just be wild type and 50% would be het for that gene. Since there is no way to tell which babies are heterozygous for the gene, all of them would be considered 66% possible heterozygous for that gene.

Two morphs that are **not allelic** (not on the same allele)
Example- Leopard Pied (male) x Pied (female)
Percentage of Leopards? Pieds? Leopard Pieds?
(Leopard is dominant, Pied is recessive)

Because they are not allelic we put each morph into a chart

PieBald (recessive)	B^W	b^P
B^W	$B^W B^W$	$B^W b^P$
b^P	$b^P B^W$	$b^P b^P$

25% of the offspring would be pied

Leopard (dominant)	L^L	l^W
l^W	$l^W L^L$	$l^W l^W$

Since the female doesn't have the leopard trait, it is only a 50% chance of the offspring getting it

Male: is heterozygous (Ll) for leopard and heterozygous (Bb) for pied. He can give one allele or the other, but not both, to any of his offspring. He can make (L), (l), (B), and (b) sperm. Equal chance for each. Since the genes are not allelic, he can make (LB), (Lb), (lB), (lb) sperm.

Female: is heterozygous (Bb) for pied, and she does not have the leopard gene (ll). She can only make to types of eggs: (lB) and (lb)

To know the percentage of leopard pied, just multiply the two 25% x 50% = 12.5%
or
Create a chart with all the possible sperm and egg types and combinations:

Leopard-Pied x Pied	LB	Lb	lB	lb
lB	lLBB	lLBb	llBB	llBb
lb	lLbB	lLbb	llbB	llbb

Pairing like alleles for convenience
- lLBB: heterozygous leopard, homozygous wild type (pied)- Visually shows leopard, no pied alleles
- lLbB (2): heterozygous leopard, heterozygous pied - Visually shows leopard, has one pied allele, but doesn't show it in the phenotype
- lLbb: heterozygous leopard, homozygous pied - Shows both leopard and pied in the phenotype
- llBB: homozygous wild type for both leopard and pied - normal, wild type colouration and pattern
- llbB (2): homozygous wild type (leopard), heterozygous pied - normal, wild type colouration, but carries the pied gene
- llbb: homozygous wild type (leopard), homozygous pied - no leopard colouration, shows pied in the phenotype

Review
Parents that show a recessive trait in their phenotype must pass it on to their offspring because they are homozygous and have only that one allele.
Parents that do not show their recessive traits are 100% het (heterozygous). The offspring of 100% het parents (that do not show the gene in their phenotype) have 66% chance of being hets (pos hets)

February 16, 2024
- We discovered we were missing a chromatophore in reptile colouration, so we fixed it. We were missing Erythrophores which produce carotenoids (red and orange) pigment. We also fixed the definition of **Xanthophores** (produces pteridine (yellow) pigments).
- Nia also changed the "Common morphs of Ball Pythons" to be "Basic Colour Morphs of Snakes" and changed some of the information to go along with it. She

removed spider and mojave and added hypermelanism, hypomelanism, anerythristic, snow, and leucism. It would be better to include these morphs because it is a simpler explanation of how the different chromatophores work, and doesn't involve a complicated analysis of the genes https://www.youtube.com/watch?v=bNYAIGet_fo

- For example, Nia learned that there were three different types of melanin that affect the animal in different ways.
- She discovered that there were two types of albinism: T-positive and T-negative. The T represents Tyrosinase which is an enzyme that helps produce the different types of melanin. T-positive snakes can still show some types of melanin just not the browns and blacks. T-negative snakes lack melanin altogether.
- We vastly expanded on the vocabulary and fixed the definition of codominant and incomplete dominant, as they are often used interchangeably but actually have different meanings.
- We are going to create charts that explain how different genes interact with each other

March 2nd, 2024
Mehnoor bought some supplies needed for the tri fold including the tri fold itself

March 6th, 2024
We worked on the section about the morphs that have genetic anomalies and how they are caused. We added lots of information about the theories as to why spider ball pythons always have the "wobble". Nia added information about **linkage** and **pleiotropy.**

Linkage means that the gene for spider and the gene that causes wobble, are present as two different genes on the same chromosome. However, there has never been a spider ball python without the spider wobble, which means that they must be located very close together on the chromosome because crossing over never has been recorded to occur. **Crossing over** is when parts of a chromosome swap with parts of the chromosome from the other parent. So, there could be the possibility of spider and wobble being unlinked. Therefore, there could be the possibility that a spider ball python could be given a "wobble" free chromosome from its parents. Since every spider ball python has been documented to have some degree of wobble, it is more likely that spider and wobble are connected through Pleiotropy. **Pleiotropy** is when one gene codes for multiple characteristics. The gene that causes spider also causes wobble. One gene has multiple effects on the genotype.

She also looked more in depth about why female desert ball pythons are unable to produce viable eggs. Although it is still unknown about what causes this anomaly, she still added a great deal of information about how it affects the snake.

Mehnoor worked on inputting our information into the CYSF website as well as finding and grouping together all the sources we used.

March 8, 2024
We continued adding more information to the anomalies section of the project

March 11, 2024
We wrote down some jot notes about the ethics of breeding morphs that have known anomalies that could potentially harm the snake.

Spider- wobble
- Only in captivity
- Wobble can impact how the snake acts, drinks, and moves around
- The person taking care of the animal can meet its needs and give it special or adjusted treatment
- Only breed spider ball pythons that have less serious forms of wobble, in the hopes of creating offspring take barely have it

Caramel- Kinking
- Kinking is sometimes harmless to the snake and is only a cosmetic issue (crooked tail)
- Sometimes kinking can impact eating or stop eating all together
- If the snake can't eat then it should be euthanized so it doesn't starve and suffer
- Kinking could cause the offspring to be unable to exit the egg (an otherwise healthy snake dies in the egg just because of a slight irregularity in the spine that wouldn't have affected it otherwise)
- Can make the snake move in an awkward way or inhibit where the snake could go
- Kinking isn't just caused by genetics, there are other factors too, such as the temperature the eggs were incubated at
- Snakes can live and survive with major kinks, even in the wild

Desert - breeding
- Lethal for females to breed
- Egg = not developed properly/cannot hatch
- Stress for females
- Slugging out
- Only breed males to continue passing down the desert gene
- Females should be kept as pets only

Cinnamon & Black pastel - Kinking & Bug eyes
- Sometimes severe → occurs due to incubation temp. (abnormally hot/cold temps.)
- Keep incubation temp. at a steady & safe temp.
- Smaller/bigger eyes don't really affect the snake
- Breed with morphs that lowers chances of kinks

March 12, 2024

After typing up some more information about the Banana ball pythons, we realized that one of our questions that we asked right at the beginning of our project does (kind of) have an answer. **“Do some morphs have a higher or lower chance of being pasted on to the offspring?”** and the answer is: sort of. Since the Banana morph is either carried on the X or the Y chromosome, it can affect how many males or females inherit the trait. For example, a male-maker banana ball python is much less likely to produce a female banana ball python compared to a female-maker banana ball python. So yes, the banana morph does affect the percentage of which sex of offspring inherit the trait, but this only applies to the fathers.

Nia also sent an email to a breeder asking a few questions to help with this project. This is how we discovered that het pied ball pythons do show some indication to their genetics, even though piebaldism is a recessive gene, it can affect the phenotype of the snake.

<u>March 13, 2024</u>
We’ve nearly finished the paragraphs for each abnormality in the morphs of ball pythons. Other than writing the conclusion and adding breeding charts to our project, we have finished the research portion for our project. For the most part, we are changing sentences to be easier to read and understand.

Here is the ethics part of this project
Is it ethical to continue breeding these animals with known and potentially lethal abnormalities?

As with all ethical questions, there is no easy answer, nor is there a truly right or wrong answer to this question. To be clear, we are only discussing the different morphs in ball pythons. We are not arguing whether or not people should keep snakes (or any animal for that matter) as pets. We are only discussing what morphs should be continued to be bred. Let’s look at both sides of the issue.

Morphs that have the wobble are only ever kept in captivity. It can impact how the snake functions depending on the severity of the wobble. The person taking care of the snake can accommodate them but if the wobble is too severe, it may end with the snake being euthanized if the snake is unable to eat. For the most part though, most cases of wobble are typically not serious and the snake can live a normal life. On the topic of breeding, the snakes with wobble should only be allowed to breed if they have a less serious form of it so it might be less severe if the abnormality was to be passed on to the next generation. A snake carrying two copies of a gene that is linked with the head wobble will often not make it out of the agg or will die almost immediately after. Therefore, it’s never recommended to breed two snakes that contain a morph carrying the wobble gene. It is safe to say that snakes with wobble should not be bred with other snakes at contain or may contain a gene that causes wobble because it could worsen the effects of wobble in the offspring and could lead to a situation where a snake has to be euthanized. However, it seems relatively harmless to continue breeding snakes with wobble to snakes that do not carry a wobble-causing gene. Therefore it does not seem unethical to or cruel to the animal to to breed or keep snakes with wobble, especially because they are meant as to be kept in captivity and have a person who can accommodate certain needs.

A morph that is well known for infertility is the desert morph, with all the females being unable to reproduce. If the female desert ball pythons are bred they are unable to produce viable eggs. There's also another possibility of the snake being unable to lay her eggs, also known as egg-bound, she would have to undergo surgery making it both difficult for the snake, but also costly. Since the morph is dominant, all the male deserts are able to create offspring that carry the desert gene. Breeding males and non-desert female ball pythons seems to be the best way to continue the desert morph. Female desert ball pythons should be kept as pets only, since breeding them proves to be unsuccessful, costly, and stressful/dangerous for the snake.

Kinking can vary from being minor and not affecting the snake's life at all to being so serious that the snake can't eat properly and would have to get euthanized. Kinking isn't always caused by morphs, it can occur from external factors such as the temperature being too hot or too cold. Aesthetically speaking, the kinks can look odd. Also, sometimes it can cause the snake to be unable to exit the egg and die in it even if it is otherwise properly developed.

Morphs with eye abnormalities can get either smaller or larger eyes. Smaller eyes could impact the ability to see but ball pythons don't rely on sight and can live while being blind quite easily. Larger eyes could increase the risk of them being damaged and could cause an infection but that in itself is very rare. Since it is mostly just a cosmetic issue, there appears to be no evidence that would point towards it being unethical to breed snakes with eye abnormalities.

In ball pythons there are head scaleless snakes (snakes that have a reduced number of scales on their heads) and scaleless or homozygous head scaleless ball pythons (snakes that are lacking all scales except their eye cap). This complete lack of scales can increase the possibility of the snake being harmed. It can also make shedding more difficult for the snake, especially as they shed more often than normal, scaled snakes. Snakes use their belly scutes to help create friction so they can move in the direction they want. If the snake doesn't have these scales it can make it much harder for them to move around.

<u>March 14, 2024</u>

We finished the paragraphs for the abnormalities in the morphs and created a data table talking about the morphs with the abnormalities, how they affect the snakes and why they're caused. We finished the conclusion and the ethics as well as creating a table of the different morphs.

We created a table and some matrices for the "data" section of the website

Morph with Known Abnormalities	**How it affects the snake**	**Known (possible) causes**
Spider	All ball pythons that inherit the spider gene get a disorder called “the spider wobble” or just “wobble”. Snakes with wobble often have unsteadiness in their heads (with varying degrees of severity)	The two theories of the causes of the spider morph being connected with wobble is: **linkage or pleiotropy.** **Linkage** is when two genes are linked on the same chromosome. **Pleiotropy** is when it’s one gene that has multiple effects.
Desert	All female ball pythons that have the desert gene are infertile. They are also often smaller than they should be for their age and sex.	It is currently unknown what actually causes the infertility in the females, especially since the males have no problem creating offspring. After breeders discovered that the females couldn’t breed, many of them gave up trying to breed the morph altogether.
Super Cinnamon, Super Black Pastel, and Cinnamon X Black Pastel	Eye defects have been commonly observed in these morphs. It is often referred to as “bug eye” when a reptile has a larger than normal eye, though they can have abnormally small eyes as well. Since ball pythons rely on their sense of smell and their heat pits, it doesn’t affect them much. Defection in the spine, also known as “kinking”, is another occurring issue with these morphs.	Again, not much research has gone into figuring out the actual cause of the eye defects and kinking. We could speculate that the reason only the super forms of the snake have the defect could be caused from inbreeding. In most animals, breeding two similar specimens together increases the risk of genetic anomalies. Another reason that the defects occur could be that the morphs already had very minor or unnoticeable problems so when they were combined together, the problems became more obvious.
Champagne, Super Champagne	Champagne on its own has nearly no problems, maybe just a minor case of wobble. When champagne is combined with any other morph that is known to have some issues, then the wobble becomes more severe.	Similar to the spider morph, champagne might have the wobble due to linkage or pleiotropy. However, since not all champagne ball pythons have wobble it seems more likely for it to be linkage.
Caramel	This morph is known for the increased chance of getting an offspring with a kink in its spine	Again, there hasn’t been much research done to confirm what is actually causing these deformities.
Scaleless	The ball pythons don’t have scales except for their eye cap. The lack	Fully scaleless ball pythons only occur if the snake receives two scaleless head alleles. That

	of scales makes shedding more difficult as they need to shed more often and it can also make the snake more susceptible to injuries. The snake can be more vulnerable to snake mites and if the snake has no belly scutes, it makes movement harder for the snake.	means that the original morph only affects a small portion of the snake (its head) and it only is fully scaleless if it is a homozygous version of the morph.
Banana	It's the only morph that is determined by chromosomes.	The gene is separately carried on the X and Y chromosomes. A female having the gene will create both female and males but a male inheriting the gene from his mother will only be able to create females as the gene is on the X chromosome. A male inheriting the gene from his father on the other hand will only procreate males.

Matrix of a Pastel x Pastel (Incomplete Dominant)

Pastel x Pastel	P^P	P^W
P^p	P^PP^P	P^PP^W
P^W	P^WP^P	P^WP^W

25% Super Pastel, 25% Wild Type, 50% Pastel

Matrix of an Albino x Het Albino (Recessive)

Albino x Het Albino	A^W	a^A
a^A	a^AA^W	a^Aa^A
a^A	a^AA^W	a^Aa^A

50% Het Albino, 50% Albino

Matrix of a Wild Type x Spider (Dominant)

Wild Type x Piebald	B^W	B^W
B^S	B^SB^W	B^SB^W
B^W	B^WB^W	B^WB^W

50% Spider, 50% Wild Type

Matrix of Wild Type x Scaleless Head (Codominant)

Wild Type x Scaleless Head	B^W	B^W
B^S	B^SB^W	B^SB^W
B^W	B^WB^W	B^WB^W

50% Wild Type (Scaled), 50% Scaleless Head Wild Type

The conclusion for our whole project:
All the data and research we have done related to the morphs and how abnormalities in them can affect the snake proves that morphs, whether they be individual or combined, can affect the different functions of a ball python. However, there is not a lot of research that has been done to discover why the anomalies happen to certain morphs. The best we can do is to use the limited information we have gathered to speculate about these different topics and create plausible explanations for them. To truly understand more about this topic, breeders and scientists would need to conduct more experiments and study, not only the abnormalities within some morphs, but also the DNA of snakes in general, before we would understand what actually causes them and if there is a way to prevent it.