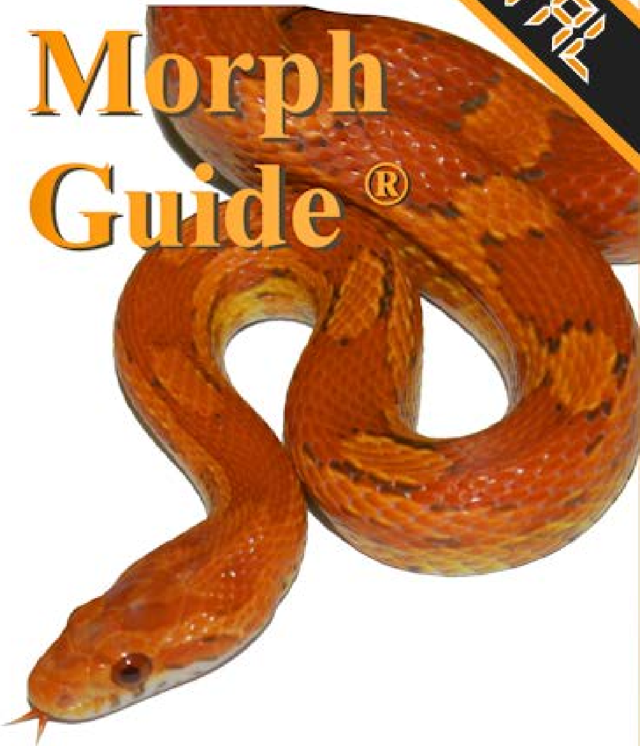
DIGITAL

Cornsnake Morph Guide ®



A Collector's, Breeder's, and Buyer's Guide to Morphology, Genetics, Pricing, & Identification

Charles Pritzel

2011 Edition

Important Notice:

This book is the result of a lot of hard work. It took a lot of time and resources to research and gather existing knowledge, experiment and discover new knowledge, and finally to organize all of it into a useful format. If you wish to say thanks by leaving me a donation, you can send money via paypal to serpwidgets@hotmail.com, amazon (or other retail) gift card, or bitcoin using the QR code, or email me at serpwidgets@hotmail.com to see what other options might be available.

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Thanks, and enjoy!
Charles Pritzel

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2011 CMG

Foreword

In the last year, prices have changed rapdily and wildly because of the economy. The prices listed in this year's edition have been left the same as last year to allow the reader at least some sense of proportion between various morph prices, with the presumption that prices can be updated again once the economy become more stable and prices return to being more predictable.

When new knowledge about our corns is introduced, it is many times greeted with dismay. The process of discovery is not about branding certain ideas as irrefutable and then desperately clinging to them well beyond their usefulness. It is a progressive venture, with each new generation of knowledge an improvement upon the last. The improvements usually come from finding and re-working the flaws in previous ideas. It is often impossible or impractical to arrive at the latest ideas without climbing the ladder of, or standing on the shoulders of, their imperfect predecessors. And it is impossible to improve upon our knowledge while assuming our current ideas are the one and only final answer.

It is important, in our pursuit of knowledge, to understand that all knowledge is provisional. Today's knowledge is probably more useful than acting as if we know nothing. Tomorrow's knowledge will be adopted if it is more useful than today's.

This guide is intended to act as a starting point and a reference, as opposed to an all-encompassing knowledgebase. Once you have a grasp of genetics and a feel for the various general classes of morphs, the best way to become familiar with the specific looks of the morphs and *all* their variations is to see as many examples of each of them as possible. Internet forums have a lot of pictures, and breeders' websites are another good resource. If you can attend reptile shows, browsing all of the tables and talking to the breeders is another good way to gain additional experience.

Given the rising numbers of double and triple genetic morphs, a new chapter on breeding schemes was added in 2008. The method presents one way of easily rolling over these double and triple combinations into quadruple and quintuple combinations. This year an illustration of the value of multi-hets was added.

Normal Cornsnakes

In order to understand what variations there are, it is necessary to be familiar with the normal appearance of cornsnakes, including natural variations on the theme.

Without any pigment the skin is transparent and the snake is pink because of the underlying flesh. This is seen in the saddles of hatchling snow corns. The rest of the colors are made by pigments or combinations of pigments and iridophores.

A normal cornsnake's colors are produced by a mixture of the following influences:

- **Melanin** – **Mel**-uh-nin, describes the browns and black pigment. As the melanin content increases, the color goes from a light tannish purple through brown and finally to black. Melanin mixed with iridophores produces a light gray, such as that found on the ground color of Miami phase and anerythristic corns.
- **Erythrin** – **Air**-uh-thrin, describes the reds and oranges. It is unknown at this time if the presence of iridophores is what makes the difference between the red saddles and orange ground colors.
- **Iridophores** – These are typically opaque white. When they are not as dense, they allow some light through and the underlying flesh can influence the color depending on lighting conditions.
- **Flesh** – The blood in the tissues underlying the scales can affect the visible color where there is nothing else to block or absorb light. These produce some pink tones.
- **Xanthin** – **Zan-**thin, describes the dark yellows which are presumed to be carotenoids collected from the snake's diet.

The typical pattern consists of several areas:

- Ground – The lighter area, usually tan to orange.
- Saddle – The darker splotches, usually red.
- Border – The dark area separating ground and saddle.
- Belly White – The white areas on the belly.
- Belly Checkers – The dark areas on the belly.

The iridophore pattern has been largely ignored, but it may help us in understanding some of the differences between morphs. Iridophores are typically present on the ground and belly white areas and dense enough to be opaque. They are normally absent in the saddle and border areas, as well as the dark checkers on the belly. In some morphs they may appear in other areas and affect the colors or patterns.

Location of iridophores: the lighter areas contain iridophores, the darker areas do not.

- The dorsal pattern consists of red saddles.
- The saddles are outlined in black.
- The ground color is anywhere from light gray to tan to orange.
- Starting from the edge of the belly to varying points on the side, there are generally one or two rows of side blotches.
- Often the blotches on the side are connected to either the dorsal saddles, or the lower blotches.
- Yellow pigment often grows in during the first year or two after hatching. It will be most visible on the sides of the jaw and neck.
- Two longitudinal stripes, generally a gray or “dirty” color, can appear along the length of the snake, at about the ten o’clock and two o’clock positions on the back.
- Two additional dark longitudinal stripes can appear, one along the middle of each side.
- The belly is similar to a basic black and white checkerboard pattern. Some color, usually red or a light red/tan, can wash over the white parts of the belly.
- A “blush” in the cheek area. This is from blood supply instead of a pigment, and thus it is present in all cornsnakes.

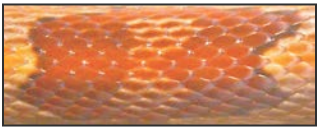
Hatchlings will start out with very little of the red, yellow, and orange coloration. To many beginners, hatchlings look like anerythristics or some “odd morph.” The saddles will be a deep burgundy or brown, and the ground color is in shades of gray or tan, with orange “dots” of color visible between the saddles, especially on the neck. The colors generally reach their peak when the snake is about 3 feet long.

There are many variations on this basic “normal” theme, all of which are still considered normal. They include, but are not necessarily limited to:

- Longer, shorter, wider, or thinner saddles.
- Fading out of two areas inside the saddles, one on either side.
- Fading out of a large area in the middle of the saddles.
- A few saddles being offset or smashed together, forming a **U** or **S** or **Z** or **W** shape.
- Thicker or thinner borders around the saddles. (Thinner borders can be gray instead of black.)
- White stippling around the outside of the black borders.
- Absent or more prominent “dark” longitudinal striping. This can also turn a light gray in adult cornsnakes.
- A great deal of variation of “general darkness” in the overall colors of the snake can be found among normals.
- Some belly checkers missing or bunched up.
- Belly checkers fading to brown, light tan, or reddish tan.
- A “stripe” of white running down the center of the belly.
- Freckling or a red wash across the belly, especially near the tail.
- Slight blurring/smudging of the lateral pattern, compared to the dorsal pattern.

The following are just a few examples of the wide variation to be found in normal cornsnakes.


White Stippling around saddles


Two saddles almost joined

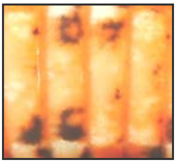

Offset or joined saddles

Some breeders select away from the white stippling around the saddles, as opposed to breeding for it.

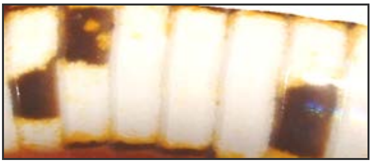

Dark longitudinal striping is especially more apparent during shed cycles


Faded areas on sides of saddles

Note that many breeders select away from the dark striping and dirty overwash of melanin, so this look is slowly becoming less common in the general population.


Belly with clear center

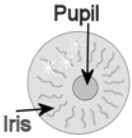

Faded Belly checkers


Missing belly checkers

Keep in mind that the same amount of variation is possible in each of the color and pattern morphs, too.

Additionally, males and females in many lines exhibit *dimorphism*, where the males are an overall lighter color, have more of a general wash of oranges/pinks, have thinner border areas, and are more prone to the "white stripe" on the belly where the checkers do not meet. These differences are usually more obvious in anerythristics and lavenders, and many bloodreds, but can also be observed in normals and virtually every color/pattern morph.

Eye Colors



The eye color consists of the iris color and the pupil color. The iris color is determined by the same pigments that form the skin colors. Iris color tends to match that of the saddles, but in some specimens it can tend toward, or even match, the ground color.


Normal

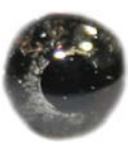

Normal

These two normals demonstrate saddle-colored versus ground-colored eyes. There could be a single gene controlling this aspect of corn eyes, but none has been isolated yet.


Amel


Snow

Both amels and snows have red/pink pupils. The snow also has cataracts, which may be common in older snakes.


Cinder


Anery


Charcoal


Hypo Pewter


Lavender

The brown/gray morphs have a wide variety of eye colors ranging from light tan to dark brown and black. With reduced melanin the color does not become light gray. Instead it becomes hazel and then blue, just like human eyes. Hypo pewters and lavenders are two of the morphs which can have ruby pupils and blue eyes.

If red or yellow pigments are present, the eyes will usually take on that coloration as the pigments grow in. In normal specimens the eyes will start out reddish-brown and then slowly turn to orange/red as the snake grows up. If only melanins are present in the iris, the color scale goes from black where the most pigment is present, and turns to brown, tan/silver, and then blue when very little melanin is present. Morphs where blue eyes have been observed include ghosts, phantoms, lavenders, hypo pewters, and neonate ultramels.

The "ghosted" group (any of the 30+ combinations of anery-like and hypo-like genes) holds the greatest potential for extremes in eye coloration.

Honey

Ghost

Phantom

Hypo Lav

The pupil color is controlled by melanin content in the retina. Generally the pupils are black, but when melanin becomes scarce enough, the blood supply present in the retina will cause the pupils to become a ruby color. In some lines of hypo and ghost corns this occurs often. Lavenders, and especially ultramel corns and hypo lavenders will typically have ruby pupils. The few known hypo pewters also have ruby pupils.

There is no dividing line where pupils suddenly cease to be black and become ruby or pink. It is a sliding scale like the difference between hot and cold. Some snakes will appear to have ruby pupils only some of the time, depending on the lighting each time you observe them.

Ultramel

Lava

The ruby eye in lavas and ultramels is most intense when they are hatchlings. As they mature they tend to gain pigmentation. The ruby eyes become darker in adults. This ultramel's pupil is just barely ruby. The lava specimen has darkened enough that its pupils appear normal.

In other species there are certain genes known to control pupil color independently of skin color, but no such genes have been demonstrated in corns to date. A "ruby-eyed" and/or "pink-eyed" gene that controls the eyes independently from the skin color could someday be located. Until such a gene is proven out, it is assumed that some hypos and ghosts which exhibit ruby eyes result from having slightly less retinal melanin than their black-eyed counterparts.

Head Patterns

There is a great deal of variety in the head patterns of cornsnakes. Although this is generally not considered a major part of cornsnake patterns, colors, or genetics, these variations can be fascinating on their own. Some of the variants appear to be inherited like simple genetic traits.

It is hoped that the American Cornsnake Registry will be an extremely useful tool in studying head patterns, and trying to determine their modes of inheritance.

- The basic arrowhead blotch is a “key.” The key can be modified in several different ways.

- The lines that connect the different parts (top, middle, bottom) can be broken on one or both sides.

“Tulip” patterns (left) can be formed by a missing center. “Smiley” and “deadbolt” patterns (right) can result from breaks between the middle and the top.

- The top, center, or bottom of the blotch can be enlarged. This “crowning” tends to create points along the edges of the blotch.

Many “club” type patterns come from enlargement of the whole blotch. Notice the crowning points on each.

- The top, center, or bottom of the head blotch can be connected to the outside of the head pattern. This can come in the form of a complete connection, or just a tendency in that direction.

The “ringneck” (found in a lot of striped corns) connects to the outsides along the back end of the blotch. Connections can be made from the middle of the key, the upper sides, or the top.

This example shows five common places where the central blotch connects to the outside:
1- Top center.

2 & 3 – left and right upper connectors, in this example connected on the left side.

4 & 5- left and right middle connectors, in this example extended on the right.

Between these five, and the two where the “ringneck” is formed, there are a total of seven main connecting positions.

- In more extreme examples, often found on corns expressing the diffused or masque patterns, a shape like a skull is apparent. It is often called a “scream” pattern because it resembles the white mask in the “scream” movies. Generally, the top point is connected, along with two pairs of points from the upper side, and the center. These leave only two oval-shaped spots.

(Left) Skull patterns on “pewter” and “bloodred” specimens.

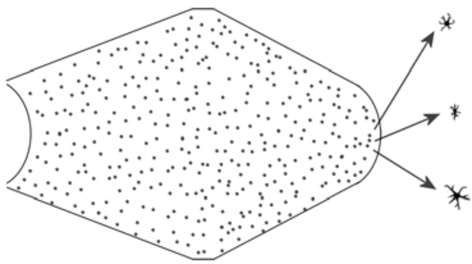
(Right) Incomplete connection of the center can leave a heart shape.

Some head patterns are not as easy to classify. The first and second examples below (“twig and berries”) look to have a key with a broken center. The other two below, like the head patterns of many sunkissed corns, seem to defy the usual descriptions.

Some head patterns appear to be more common in certain morph types. This may or may not be a good indicator of the ancestry of a cornsnake, so in most cases it’s not a good idea to use it as a method of identification. So far, very little work has been done on the inheritance of head patterns.

Hypermacro Morph Identification

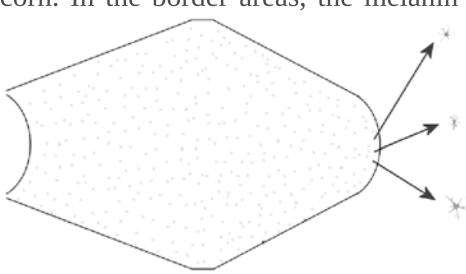
Upon close examination of scales on various corns, one can see tiny black specks or dots present on normal corns. These are absent on amelanistic corns, which suggests they contain melanin. Since each dot can be seen individually with extreme magnification, it was hypothesized that the hypo-like morphs could result from different modifications to this scheme, and that some of these differences might be visible at this level of magnification.



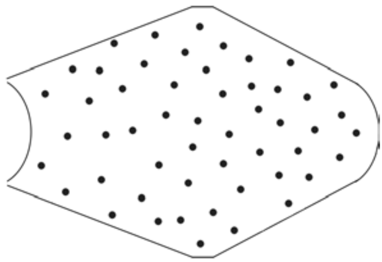
The specks are normally shaped like 'splat' marks or neurons with dendrites coming out of them.

For example, one way to make a corn look like a hypomelanistic is having the same number of black dots but each of a lighter color. Another way is to leave the color alone and spread them out, so there are fewer of the dots. If these differences could be observed, it would be possible to make accurate morph identifications without breeding trials.

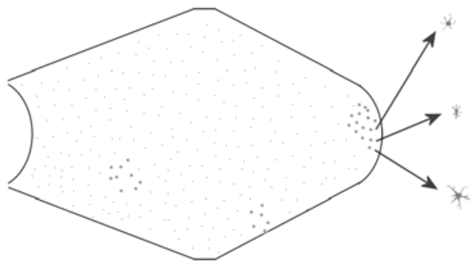
With this hypothesis in hand, normal, hypo, and ultramel corns were observed at 100X and 250X magnification. There was no obvious difference in the dot count, shape, or darkness between normal and hypo corns at first, but there were no visible dots on the ultramel corn. In the border areas, the melanin was visible on the ultramel, but it is a very light gray instead of opaque black. Further observation using known ultra and ultramel specimens suggests that ultras can be identified by their more opaque dots compared to ultramels.



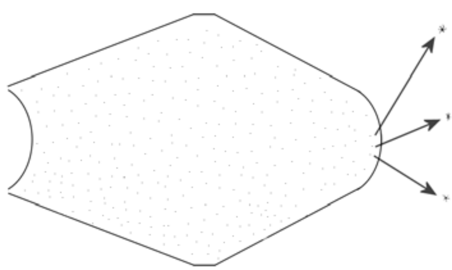
The same inspection of sunkissed corns revealed that the dots are mostly circular with few or no visible protrusions. They are adendritic, lacking dendrites. They are also larger than typical, and more spread out. At higher levels of magnification the shapes are easier to identify, but it can be difficult to see when the specimen is only in focus for a fraction of a second, so it may take some practice learning to steady the subject. The dots on dilute corns looked very similar to sunkisseds but were noticeably larger.



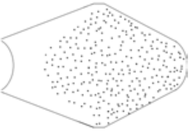
Lava also appears to be easily identified with a hypermacro inspection. The dots are either missing or extremely tiny across all but small patches of the ground area. Later tests revealed that the opacity varies throughout a shed cycle. The dots are most transparent just after shedding, and most opaque just before shedding. In the saddle areas the patches containing dots were more frequent and larger. The shapes of the dots were normal, but they had the appearance of being buried underneath a layer of plexiglass.



Hypo corns did turn out to be different from normal. The dots are not completely opaque but otherwise the same shape and size as normals. Strawberry corns had very tiny spots that varied in opacity throughout the shed cycle, in the same way as lavas. Since strawberry and hypo are alleles, this is a convenient way to separate strawberry from hypo lines. Het hypo/strawberry is identifiable because the two dot types form a cellular mosaic: each



dot is either a “hypo” dot or a “strawberry” dot. It is best to check shortly after a shed so that the differences between hypo dots and strawberry dots are maximized.



In several specimens the spots only reached most of the way across each scale, and there was an empty area at the front end of each scale, where the neighboring scales would overlap it. This was seen in several different morphs from various bloodlines so it is probably not associated with any currently known color or pattern gene, but it seemed at first glance to run in family lines, especially sunkissed corns.

Charcoal and anery were also examined. No obvious differences between those two were noticed at the time. Lavenders did have smaller spots with few to no dendrites, so be mindful of this if you are trying to determine whether a lavender is a hypo, lava, dilute, etc. This also helps to explain why lavenders appear hypomelanistic.

Other morphs such as caramel, cinder, diffusion, motley, etc can be interesting to look at with this method, but no distinctive characteristics were found for any of these genes, at first glance, and since it is generally not an issue trying to identify which snakes are expressing these genes, they were not examined as thoroughly. Other characteristics were noted: the spots on the head are not typical of those on the body, and the spots become sparse on the last few scale rows before fading out at the edge of the belly.

With many other sets of eyes looking at corns snakes in this way, it is likely that other such differences between morphs will be noticed in the future. It is also possible that hets for some genes are visible with this type of examination, which would eliminate “possible hets” for that gene and help breeders skip test crosses.

The technique for this is simple and inexpensive, so any hobbyist or breeder should be able to use it. You will need a microscope or loupe which can be used at approximately 100X, a bright light shining on the snake from above or the side, and a model for comparison depending on which morph you are trying to identify. Be sure your scope has a setting of approximately 100-200X. Higher magnifications make for an extremely jittery view and it becomes impossible to see anything this way.

There are many brands of cheap microscopes for children available at departments stores for as little as $20. Radio Shack has an illuminated mini microscope (model# MM-100 catalog# 63-1313) for about $12 which does a very good job and is pictured here. A cheaper $6 illuminated 60X-100X scope was also tried but it was unable to focus well enough to see any details with reasonable clarity, and is not recommended for this purpose. The advantage of a microscope with a larger objective lens is that you get a larger field of view, and a more expensive scope with better optics will be able to focus more sharply. The above microscope shows an entire scale whereas the mini microscope shows only about a quarter of that amount.

With microscopes you tend to get what you pay for. The cheapest models have very low quality and small field of view. A high-end (hundreds to thousands of dollars) microscope is not necessary for 100X viewing. An $80-100 model is well worth the price tag for the quality you get. Digital and USB scopes tend to be much more expensive and anything lower than a few hundred dollars tends to lack the needed picture quality, especially on a moving subject.

Hold the snake under the lens and use your hand to move the snake so that it comes into focus. If you are using a microscope with a snake who will sit still, you can rest a coil on the plate where you normally put the glass slides, and then use the focus wheel. Since the snake is round and its scales are curved, only a small area will be in focus at any time. The higher your magnification, the smaller your area of focus will be, so this is another reason to keep the magnification level low.

Keep in mind that the above observations were based on a small sample of specimens. They are not presented as absolute rules. Instead, they are a starting point. Further observations can help to find which morph characteristics are consistent.

Pattern Formation

This chapter presents a hypothetical model of pattern formation. While it is written in the sense that the model is not hypothetical, this is only done for ease of language: to avoid constant repetition of "in theory" or "hypothetically" in every sentence. Real biological processes are often insanely complicated, so it's possible that this model, even if mostly accurate, is greatly oversimplified.

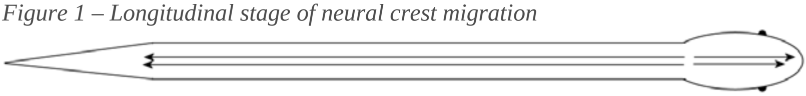
The process can be broken down into several steps:

- Neural crest migration
- Spinal closure
- Scale formation
- Cellular automaton

Neural Crest Migration:

The first step is the neural crest migration. This was described in previous editions of the CMG, but the previous model has been expanded to include more details. The migration stage of the process is where cells (the ones which will eventually produce the pigments) start at the neural crest near the back of the brain, and migrate in both directions along the length of the snake, toward the tip of the tail and the nose as shown in Figure 1. When this first stage is slowed or stopped prematurely, the result can be a lack of pigment/pattern on the nose and/or tail.

Figure 1 – Longitudinal stage of neural crest migration



Next these cells migrate from dorsal to ventral, downward along the sides. Slowing or premature stopping of this stage can produce a lack of pigment/pattern on the bottom of the snake. This process appears to be common to all vertebrates, and explains why so many species have varieties with non-pigmented bellies and extremities. In the case of humans, we lack pigment on the palms of our hands and bottoms of our feet.

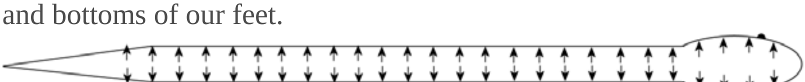


Figure 2 – Lateral stage of neural crest migration

Spinal Closure:

The next event is spinal closure. In embryos the skin begins in two halves (left and right) which are not joined at the belly or back. Closure is when the two halves are fused together. When closure fails to happen normally, the consequences are conditions such as spina bifida (where the spine is exposed), anencephaly (being born with the brain on the outside of the body), or when the ventrum fails to fuse, abdominoschisis (being born with organs on the outside of the body.)

The timing of closure relative to migration, scale formation, and the cellular automaton can also have an effect on the pattern. If the pattern is completed before spinal closure, the left and right halves will have been formed independently and may produce pattern anomolies such as zigzag saddles.

If spinal closure occurs before pattern completion, the left and right halves will be aligned. Zigzag and similar pattern anomolies will be much more unlikely. If, for example, the sunkissed pattern continues forming after ventral closure, the result could be sunkissed corns having many more checkers extending all the way across the belly scales.

Scale Formation:

Scale formation occurs when the skin changes from a smooth sheet into separate scales. Since corns with split scales along the back are not found, it is logical to presume that scale formation takes place after closure. The timing of scale formation relative to the cellular automaton stage could explain differences in the smoothness or jaggedness of edges between saddles and borders, such as the jagged borders found on some cinder corns.

Cellular Automaton:

The last step in pattern formation can be described as a cellular automaton or "CA." This is a group of individual objects known as cells laid out in an array (*see Figure 3*) that each behave individually according to the same set of rules. These rules involve interactions between neighboring cells. Typically this is something simple such as, "if this many neighbors are on, switch on, otherwise switch off." Cells may be allowed to take one of two states (on / off, *see Figure 4*) or there can be more states (red / green / blue, *see Figure 5*) or any number of states. When the automaton is put into action the cells each act locally, but larger patterns can emerge within the array of cells. The resulting patterns depend on the rules and the starting states of the cells.

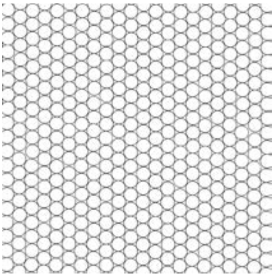


Figure 3 – A patch of cells

A patch of skin on an embryo is very similar to the CA model. Skin cells of the embryo are arranged in a mostly two dimensional lattice. Each cell in the skin can "broadcast" its state to other cells by way of hormones which are manufactured within the cell and diffuse out into the surrounding cell population. Each cell can "listen" to its environment using receptors which detect the absence or presence of those hormones. The number of receptors triggered by this hormone can initiate another process within the cell such as the activation of one or another gene, causing the cell to produce one pigment or another.

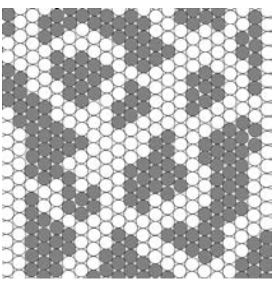


Figure 4 – Cells with on or off states form a pattern.

One of the simplest CA models is the radius-threshold model. Each cell begins in a random state (on or off) and then sets its own state depending on how many of its neighbors are on. This magic number needed to change states is called the "threshold." If the count is more than the threshold, the cell changes its state to “off.” If it’s less than the threshold, the cell changes its state to “on.” The "neighbors" don’t consist simply of the cells touching it, but include all nearby cells within a certain distance. This second parameter, the distance, is called the "radius."

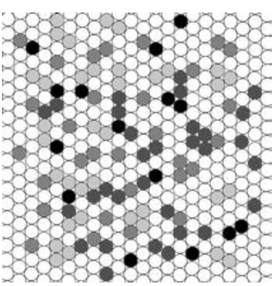
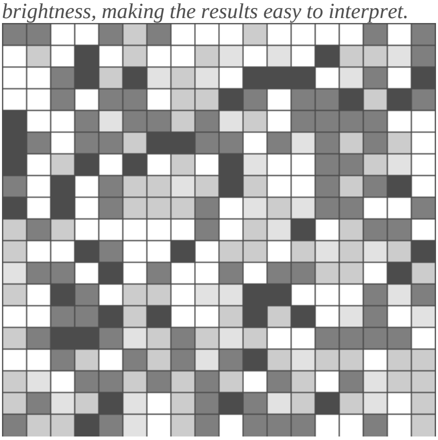


Figure 5 – A patch of cells with multiple states.

While a CA itself is very simple, and it seems intuitive to us at first glance, the results typically defy human intuition. Small changes to a rule or value can make very small or very large differences in the results, and the relationships between inputs and outputs can be very unpredictable. The best way to understand the result of a change in parameters is to make the change, run the process as either a computer simulation or a controlled experiment, and then observe the results when completed.

22	13	70	95	15	42	24	98	80	98	43	97	87	73	72	29	86	14
89	46	74	10	90	38	71	72	54	60	94	64	84	4	46	37	57	29
82	81	17	4	51	6	64	52	57	69	6	3	7	68	66	25	73	2
83	82	26	76	19	10	68	40	46	2	31	95	33	31	4	54	6	26
5	84	84	26	60	21	32	36	31	57	48	93	34	15	34	22	84	68
9	16	93	30	21	40	9	2	18	12	81	12	61	12	46	26	50	97
4	90	35	5	90	1	88	55	88	2	60	83	68	13	18	51	56	84
34	96	8	94	33	50	53	59	50	5	40	95	75	25	46	25	4	67
9	69	3	78	24	46	42	46	22	77	59	39	60	32	31	96	98	27
38	11	49	97	83	86	88	86	32	85	46	61	4	72	43	12	29	90
40	72	86	0	11	80	74	7	75	37	38	96	38	62	48	55	44	4
64	25	20	83	7	75	15	81	68	20	95	18	29	52	40	79	6	36
38	82	10	19	84	42	42	90	59	65	1	6	75	90	89	19	64	15
85	91	24	11	1	52	5	75	71	43	3	43	2	92	64	31	88	63
37	13	8	4	28	66	53	25	37	59	44	86	92	11	28	11	32	89
67	74	14	44	70	34	38	12	56	15	8	39	67	43	46	87	36	51
46	57	83	28	12	38	16	38	22	46	98	28	37	89	30	61	51	47
55	21	55	44	3	59	97	54	14	1	23	66	50	7	40	65	90	45
27	53	55	3	29	65	80	50	12	97	22	31	20	84	75	24	68	52

Figure 6 – Numbers generated by a computerized CA (above) are displayed (below) using color or brightness, making the results easy to interpret.



One of the great things about cellular automata is that they are easily translated into computer programs. For ease of viewing and analysis, each cell’s state can be displayed graphically with colors or shapes as shown in Figure 6. When a computer executes a CA program, the user can watch the pattern emerge out of a field of random noise and take shape. The rules or starting conditions can easily be changed and the simulation re-run. The new result is then visible within a few seconds or minutes.

The radius-threshold model, as described above, can be used to produce several realistic cornsnake patterns including variations of normal, motley, stripe, tessera, and banding typical of milksnakes and california kingsnakes. Adding a timed separation between left and right halves can produce additional patterns such zigzagging and twin-spotting.

A sample of the resulting patterns is shown in Figure 7. The reader should realize that all of these patterns were produced by changing *only* the threshold and radius. The machinery behind each of these patterns stays exactly the same through all variations.

The point of this illustration is that although many patterns appear to be unrelated to each other, the difference between saddles and stripes can be something as seemingly insignificant as a slight change of a single hormone’s stability (how far it diffuses before decaying, affecting the radius), or its size (how easily it diffuses, affecting the radius), or its shape (how good it is at activating its receptor, affecting the threshold) or any number of other variations that could change the resulting radius or threshold.

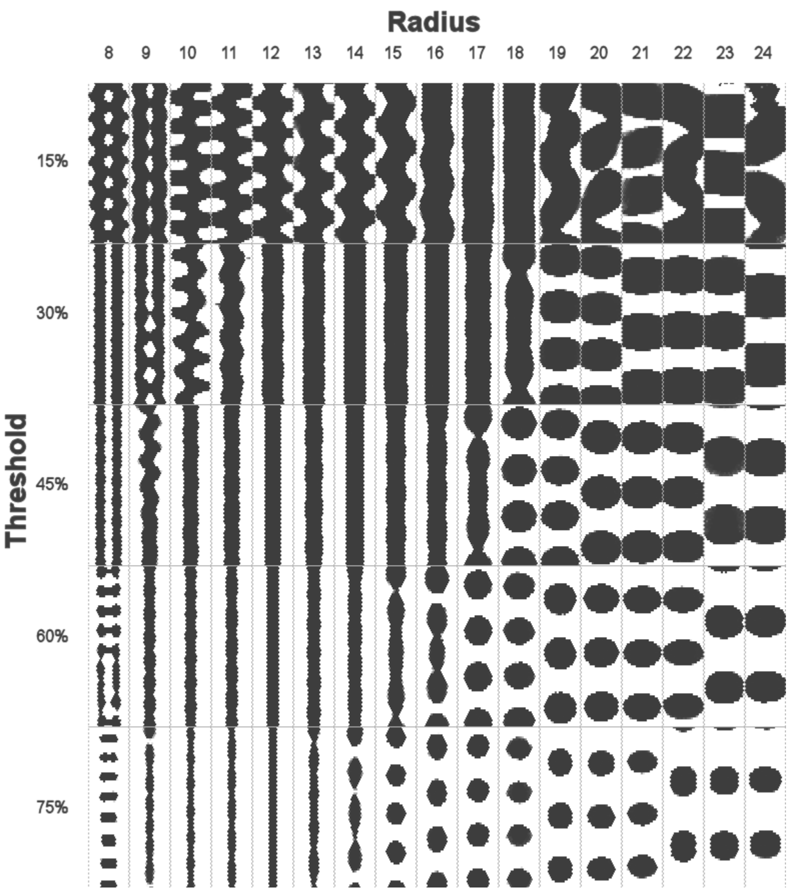


Figure 7 – Various patterns produced by the Radius-Threshold model.

The patterns formed by cellular automata are emergent. That is, they are not a direct result of the rules. Small changes in the rules, or the starting states of the cells, can make drastic differences to the final result. These results show not only a difference in degree, such as making larger/smaller spots or thicker/thinner stripes, but as illustrated, differences in the nature of the pattern such as round spots becoming long stripes or horizontal bands, or saddle shapes.

The same types of patterns are seen all over the animal kingdom from fish to reptiles, snakes, birds, and mammals. Given this, it seems likely that the same basic mechanism is responsible for producing the patterns across animal species, with the differences being a result of various tweeks to the parameters, rather than wholesale changes to the entire pattern-making machinery. Therefore, it should come as no surprise when we find patterns in one species that resemble the patterns of another, even when the species are not closely related.

The Reaction-Diffusion Cellular Automaton:

Another set of rules for a cellular automaton is known as reaction-diffusion, and the concept dates back to at least the 1950's. The reaction-diffusion system involves two different molecules moving throughout the patch of cells, and has the following properties.

- The two types of molecules are known as U and V.
- U diffuses through the cells, from cells with higher concentrations into neighboring cells with lower concentrations.
- V diffuses in the same way as U.
- When U and V collide they undergo a chemical reaction, turning U into V.
- Molecule U is also present in underlying cell layers so that more of it diffuses into the skin after it is used up in the reaction with V.
- Molecule V eventually breaks down into a third product P which doesn't interact with U or V.

The resulting level of one or more of the above molecules would then trigger a cell to produce (or not produce) one or more pigments, thus a pattern of different colored cells would become visible.

By adjusting the rates of the above processes, and graphically displaying each cell's concentration level of either U, V, or P, a great variety of striped and spotted patterns can be produced. Many of them are similar to patterns found in the animal kingdom.

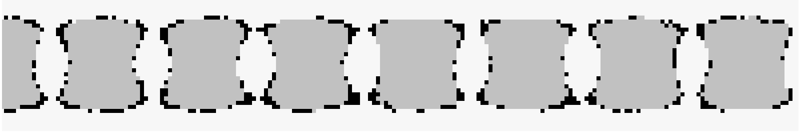


Figure 8 – A normal cornsnake saddle pattern made by a reaction-diffusion CA.

An example of the potential of the reaction diffusion system to make realistic cornsnake patterns is this saddle pattern. In Figure 8 the concentration level of molecule U is displayed for each cell. The levels are made more visible by drawing all concentrations between two thresholds as the same color. Changing the thresholds to draw border or saddle colors at different U-levels also highlights the subtle longitudinal stripes of melanin found on many cornsnakes. This can be seen in Figure 9.

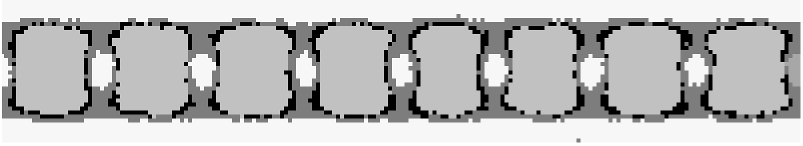


Figure 9 – Adjusting the thresholds for the result from Figure 8 also shows concentrations of U where the dark longitudinal stripes would typically appear.

Figure 10 shows a zigzag pattern made by the reaction-diffusion simulator.

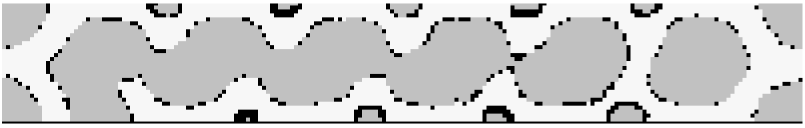


Figure 10 –A familiar zigzag saddle pattern produced by a reaction-diffusion CA.

The reaction-diffusion model is much easier to understand by observing it, rather than reading a written description. As a supplement to this chapter the cornguide.com website has java applets to demonstrate the reaction-diffusion and radius-threshold models in action.

Previously the CMG had presented a model for pattern formation based on neural crest migration. This model has been improved and updated by adding the cellular automaton, spinal fusion, and scale forming events. Further improvements to the model or simulators may be published on cornguide.com as they are developed.

The Genetic Recipe

Genes are often described as a blueprint, but a better analogy can be made to a recipe. This chapter is intended to help readers better grasp the roles genes play by illustrating that analogy. For example, let's look at a recipe for making chocolate chip cookies.

- Preheat oven to 350F
- Get a large mixing bowl
- Measure 2 eggs
- Measure 2 cups flour
- Measure 1 cup sugar
- Measure 1 tsp salt
- Measure 1 tsp vanilla
- Measure 1 cup butter
- Mix thoroughly
- Measure 2 cups chocolate chips
- Mix in the chips
- Drop onto baking sheet in separate small globs
- Put baking sheet in oven
- Set oven timer for 10 minutes
- Remove from oven when timer goes off

A blueprint does not say how to hammer nails or cut boards in order to build a structure. It shows what the object should look like after it is built. A recipe is very different from a blueprint. Instead of a description of the finished product, the recipe is a series of steps to take in order to create the finished product. Each gene might be like one line (or even part of a line) in a recipe.

Also, the parts of a blueprint directly correspond to parts of the product. If you were to erase part of a blueprint, that same part would be missing from the completed object. One part of the recipe doesn't specify one piece of the resulting cookies. If you remove one line from the recipe, such as the eggs, it doesn't make partial cookies or a batch with some cookies missing. It would change the nature of all of the cookies in the same way.

The idea of a recipe is simple enough, but the genes in real animals have one property that makes things a little more complex: they come in pairs. One copy is carried in the sperm cell, the other copy in the egg cell. The vast majority of genes are inherited from both parents in this way. This means there can be two different instructions for the same step of the recipe. The basis of Mendelian genetics is understanding how these differences are worked out in order to produce a particular plant or animal.

Let’s consider our recipe again. Imagine that there are two chefs working together, each following their own copy of the recipe. If both chefs have the same recipe shown above, the cookies would come out normal. When the two recipes are different, there are two basic ways to work out the difference. We need one bit of terminology before we can go forward.

Locus and Allele:

The term “gene” can be tricky, since it can be used in two different ways. First it can mean one particular line of a recipe. It can also mean one of the variations found at that particular line of a recipe. To distinguish between these two, the term “locus” is used to specify the part of a recipe where a particular instruction is found, and “allele” is used to specify the actual variant of that instruction.

For example, the “preheat” instruction might be 350F, or 400F, or 450F. Different recipes might have variations such as:

	“350” allele	*“400” allele*
“Preheat” locus ⇨	Preheat oven to **350**F	Preheat oven to **400**F
“Sugar” locus ⇨	Measure 1/8 cup sugar	Measure 2 cups sugar
	“bland” allele	*“sweet” allele*

The most common variation at a locus, or the one we tend to consider normal, is also called the “wild-type” allele. Any other alleles at that locus are known as “mutant” alleles. There is no limit to how many different alleles can be present in the population. There could be a hundred or more different alleles at the preheat locus. The wild-type gene is commonly assumed to have some special, almost mystical property. But the only way it differs from the others is that humans have arbitrarily chosen to call it the wild-type. The wild-type allele at a locus is not necessarily better, superior, or the one that is "supposed" to be there. It is just the one we would expect to find if we captured a wild specimen.

Note that "wild-type" is different for each locus, too. At the preheat locus it is the "350" instruction. At the sugar locus it is the "1 cup" instruction. At the timer locus it is the "10 minutes" instruction. This is also true in real genes. The wild type allele for the piebald locus is not the same as the wild-type allele for the albino locus.

Since each individual has inherited one copy from each parent, at each locus there are sometimes two different alleles paired up in the same individual, such as one instruction which says to use 1/8 cup of sugar, and the other says to use 2 cups of sugar. We need to understand how these different pairings can affect the result. This is the essence of Mendelian genetics and breeders can benefit greatly from understanding it.

Dominant/Recessive Relationships:

Let's imagine that one chef's recipe is missing the line that says "mix in the chips." What will happen? The other chef will still mix them in, and the cookies will come out normal. This missing instruction has no effect on the cookies. But if both chefs' recipes are missing that line, the chips would not be added in, and the resulting cookies would have no chips. (We might even call them "chip albino" cookies.) Figure 1 shows the various pairings of the "wild-type" and "no chip" alleles at the "chocolate chip" locus.

Chef 1	***Chef 2***	***Result***
Chips	Chips	Normal Cookies
Chips	NO Chips	Normal Cookies
NO Chips	NO Chips	"Chip Albino" Cookies

Figure 1 – Dominant/Recessive relationship

This relationship is called dominant/recessive. Any two alleles can be paired in three different ways. When two of these ways produce the same result, one of the alleles is dominant and the other is recessive. The dominant allele is the one that produces the two identical outcomes. In this case, the "chip albino" allele is recessive to its "wild-type" allele. Dominant and recessive are relationships. An allele is not dominant or recessive by itself, it must be dominant or recessive *to* another allele.

Codominant Relationships:

Now let's imagine another scenario, a recipe where the chip instruction has been altered to say "butterscotch chips" instead of "chocolate chips." What will happen when these two are paired together? Each chef will add their type of chips, and the cookies will have both chocolate and butterscotch chips. Meanwhile, if both chefs have the "butterscotch" version, the cookies will have butterscotch chips and no chocolate chips. Figure 2 shows the various pairings of the "chocolate" and "butterscotch" alleles at the chip locus.

Chef 1	***Chef 2***	***Result***
Chocolate	Chocolate	Normal Cookies
Chocolate	Butterscotch	Mixed chip Cookies
Butterscotch	Butterscotch	Butterscotch Cookies

Figure2 – Codominant relationship

In this case, mixing the two alleles in the three different ways produces *three* different outcomes. Each allele has some effect on the outcome when they are paired together. This is a codominant relationship. Each allele is *codominant to* the other.

Note that being "dominant" or "recessive" or "codominant" is not a built-in property of an allele. It is only that allele's *relationship* to another allele, in the way that it affects or doesn't affect a particular characteristic in the presence of the other allele. The same allele can be dominant to one, codominant to another, and recessive to another.

Mosaics:

When two characteristics are both present, the result is not always a smooth blending of the two. Another way for two different characteristics to be expressed at the same time is called a mosaic. Let's consider what would happen if each chef's recipe started by instructing them to eject the other chef. In some cases the "chocolate" chef might succeed, and other times the "butterscotch" chef would win. The same exact pairing would sometimes produce a whole batch of butterscotch cookies, and other times it would produce a whole batch of chocolate chip cookies.

When this happens in each of millions of skin cells, the outcome could vary for each cell individually. To the naked eye the skin would look like an intermediate or blending between the two types.

But this battle to determine which trait to express can also happen earlier, before all of the cells have divided to form the skin. When these early cells divide to become daughter cells with the same fate as the cell they came from, they go on to produce large patches of skin of the same type, similar to what we see on piebald, calico, etc. In cornsnakes, the lava morph and the hypo/straw morph both form mosaics of two different cell types.

Genotype/Phenotype:

A few other terms are often needed to describe situations or concepts we encounter. The first are phenotype and genotype. The genotype is the pair of alleles actually present. Phenotype is the visible or detectable characteristic, such as body shape, size, a preference for a certain food, or a lack of pigment. See Figure 3.

Genotype	***Phenotype***
Chocolate · Chocolate	Normal Cookies
Chocolate · Butterscotch	Mixed chip Cookies
Butterscotch · Butterscotch	Butterscotch Cookies

Figure 3 – Genotype vs Phenotype

Homozygous/Heterogygous:

Genetics terms, like genes, often come in pairs. The other important pair of terms is homozygous and heterozygous. Homozygous means that the two alleles paired at a locus are identical. Heterozygous means that the pair of alleles at a locus are different. See Figure 4 for examples.

Chocolate	NO Chips	***Heterozygous***
Butterscotch	NO Chips	***Heterozygous***
Chocolate	Butterscotch	***Heterozygous***

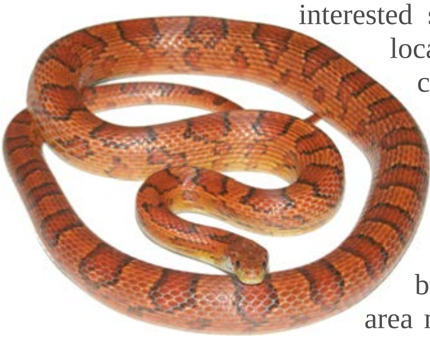
Butterscotch	Butterscotch	***Homozygous***
Chocolate	Chocolate	***Homozygous***
NO Chips	NO Chips	***Homozygous***

Figure 4 – Homozygous vs Heterozygous

Selectively Bred Variations

Note that only the most common selectively-bred morphs are covered here. It is possible to select for any particular set of characteristics and many breeders have their own distinct lines. Just because a morph is not covered here does not mean it has not been honed by a breeder to bring out certain traits.

Okeetee (Okeetee Phase)
Pronounced “Oak-uh-tee.” There are two main uses of this word:



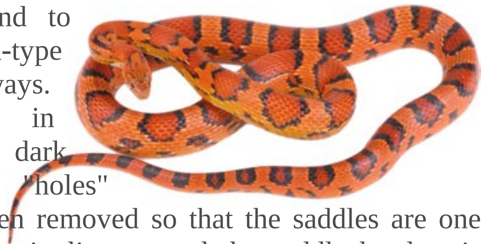
The original meaning refers to a locality, and some people are interested specifically in corns from this locality. The stereotypical Okeetee corn has extremely bright orange and red colors separated by thick, bold black borders. Okeetees are generally considered the most attractive natural variation of cornsnake, but not all specimens from this area match the description. They are also referred to as *Landrace*, *Hunt Club Corns*, or *True Okeetees*, in an effort to distinguish them from the second type. The American Cornsnake Registry can help to track the lineage of these animals to retain locality information.

Another meaning has branched off from this, and is perhaps more common than the original. It refers to corns having the stereotypical “look” of Okeetee locality corns. Many of these have been produced from various bloodlines. They will have some, little, or no connection to any corns from the actual locality. They are also sometimes referred to as “look-eetees” or “Okeetee Phase” in an effort to ensure the buyer doesn’t assume they are locality corns. Cornsnakes cannot be het for Okeetee or Okeetee Phase.

Sub-varieties of Okeetees:

Many breeders have a special admiration for Okeetee corns and have been breeding them to improve upon the wild-type Okeetee look. The two most well known are Kathy Love's Okeetees, and Lee Abbott's Okeetees.

Photo by Bill & Kathy Love – Cornutopia.com



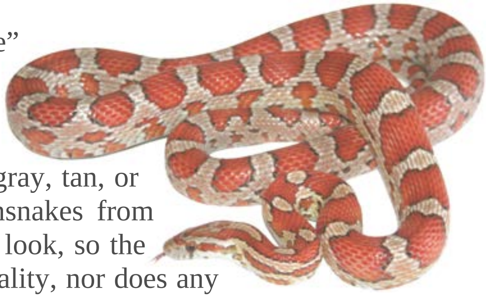
The **Love's Okeetees** tend to stand out from wild-type Okeetees in several ways. Kathy has succeeded in breeding out the dark longitudinal striping. The "holes" inside the saddles have been removed so that the saddles are one solid color, and the white stippling around the saddle borders is absent or reduced. The other distinctive quality of Love's Okeetees is that each color on the snake is extremely smooth, instead of being speckled.

The **Abbott's Okeetees** are most well known for the extreme thickness of the black bordering. In some examples, the saddles near the tail end of the snake are solid black or nearly so, with little or no red color to be found inside the borders.

Photo by Don Soderberg – South Mountain Reptiles

Miami Phase

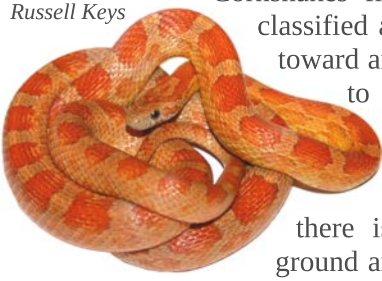
The name "Miami phase" was coined to describe a look that is often found in corns coming from that area. The ground color is gray, tan, or somewhere between. Cornsnakes from anywhere can take on this look, so the name does not imply a locality, nor does any corn coming from that area automatically qualify as a "Miami phase." Hatchlings have a clean gray ground color. Individuals with



the least traces of orange on the neck tend to turn out with the cleanest gray ground colors as adults. Cornsnakes cannot be het for Miami phase.

Upper Keys corn, Keys corn, Rosy Ratsnake

Photo by Russell Keys



Cornsnakes from the Florida Keys used to be classified as a separate subspecies. They tend toward an overall lighter appearance, similar to hypos. The belly checkering is generally not as strong, or is even absent. The ground color tends more toward shades of tan, and there is generally less contrast between ground and saddle colors. The black borders around the saddles are less prominent than in typical corns, or entirely absent. Cornsnakes cannot be het for "upper keys" or "rosy ratsnake."

Kisatchie, *Slowinskii*

These come from certain areas of Louisiana and Texas, and are thought by many to be an intergrade of cornsnakes and emoryi ratsnakes. The new classification, which separates Elaphe into Pantherophis, considers them a separate species: *Pantherophis slowinskii*. Colors are in dark browns and grays and can look somewhat like very dark anerythristics. Cornsnakes cannot be het for Kisatchie.

Photo by Don Soderberg – South Mountain Reptiles

Photo by Don Soderberg – South Mountain Reptiles

A gene for anerythrism has appeared in kisatchies. The first were produced by Don Soderberg, which he calls "black kisatchies." It is unknown at this time if this is an allele to any of the corn anery-like genes, or at a new locus.

Milksnake Phase, Banded

Banded cornsnakes have been bred to have wide saddles, or saddles which connect to the side blotches for a banded look.

The milksnake phase lines are intended to resemble eastern milksnakes. They were started with Miami corns, and as a result tend to have a light/clean ground color. Milksnake phase corns have also been crossed into motley lines. Carol Huddleston is investigating to see if they are in any way related to sunkissed motleys, since some of these retain checkering combined with a motley-like appearance.

Cornsnakes cannot be het for milksnake phase, or banded.

Aztec, **Zigzag**

The zigzag pattern results from the left and right sides of the saddles being offset from each other, creating a "zipper" type of pattern. This can occur on anywhere from a single saddle to all saddles. Generally a snake is not considered a zigzag unless 80% or more of the saddles are zigzagged. Specimens with less are often called "partial zigzag" or "partial aztec" instead.

Partial zigzag pattern

Aztec is an aberrant pattern that often has small pieces of colors strewn about, as if the saddles were made of glass and had been shattered. As with zigzags, a little, some, or all of the pattern may be affected, and individuals with a large amount of the aberrant aztec pattern are valued.

Aztec pattern

Some individuals will show both zigzag and aztec type patterning. Individual cornsnakes can have varying degrees of either of these patterns, and both types can mix and meld between one and the other, so there is plenty of gray area between what is considered zigzag and what is considered aztec.

Selective breeding of the most extremely patterned individuals generally creates the most extremely patterned offspring. These are very unpredictable patterns. Sometimes crosses – even between parents with the best patterns – produce normally patterned offspring. In other cases, normally patterned parents can produce extremely odd patterned offspring.

Cornsnakes with aztec or zigzag parents are commonly listed as “het” for zigzag or aztec. Do not assume they will produce these patterns in the same way as proven genetic traits do.

Other variations…

Many breeders selectively breed to establish certain looks in their own lines. When they are satisfied that a line is sufficiently different to warrant a name, they will apply one.

On the other hand, some breeders or resellers will simply apply a name in order to try to sell their product more easily, because it implies that the snakes are “special.”

Do not assume that a cornsnake with an unrecognized name is automatically special, but don’t assume it is a scam either. If you think they would be a good addition to a breeding project, ask the breeder some questions, such as:

- What is special about the individuals with that name?
- How were they produced?
- Are there any known genetic traits involved?
- Do they “breed true?” (If I breed two of these together, will the offspring look like these?)
- Are there any other unusual or notable tendencies (good or bad) in that line?

Someone who has worked hard on a project will have a lot to say about them. Someone who has simply attached a name in order to sell something will not have much to say.

Either way, that type of corn still may be a good addition to your projects, but it’s helpful to have as much information as possible about what you are working with.

Genetic Morphs

To understand all of the genetic traits involved in corn morphs, it is vital to know how *all* types of traits work, instead of memorizing results of crosses involving recessive genes. Genetics For Herpers is highly recommended reading for anyone wishing to learn how it all works.

Readers unfamiliar with the terms *locus* and *allele* need to familiarize themselves with these concepts in order to work with genetic cornsnake morphs. Many hobbyists continue to practice and teach pseudogenetics, especially in other species. Any explanation of genetics that does not include these terms is insufficient to deal with the reality of cornsnake traits as they are known today.

Example pictures should not be used as an absolute standard or identification method. Some traits will mimic each other -- such as charcoal and anery, and ultra and hypo -- so a visual identification may be insufficient. Just because your snake looks more like the ultra picture than the hypo picture, does not mean your snake is an ultra. When the specific gene is unknown, breeding trials or other identification methods are necessary to find which gene is involved.

Common Names - While all genetic combination morphs can be identified by a listing of the genetic components, a few morphs are sometimes called by a more fanciful name. These common names or "trade names" are not intended to be an exact description or color swatch of the morph, but to present a more "artistic" version. Some are more commonly applied than others.

Snow – amel, anery
Blizzard – amel, charcoal
Butter – amel, caramel
Opal – amel, lavender
Ghost – hypo, anery
Phantom – hypo, charcoal
Amber – hypo, caramel
Topaz – lava, caramel
Platinum – hypo, charcoal, anery
Orchid – sunkissed, lavender
Peppermint – amel, cinder
Saffron–sunkissed, amel, caramel
Pewter – charcoal, diffusion
Ice – lava, anery
Granite – anery, diffusion
Golddust – ultra/ultramel, caramel
Fire – amel, diffusion
Avalanche – anery, amel, diffusion
Whiteout – charcoal, amel, diffusion
Sulfur – caramel, amel, diffusion
Plasma – diffusion, lavender
Honey – sunkissed, caramel
Diamond – lava, charcoal
Mandarin – amel, kastanie

The Albino locus:

Allele	Name
A^+	Wild Type
a^a	Amelanism
a^u	Ultra

Genotype	Known as:
$A^+ \cdot A^+$	Wild type
$A^+ \cdot a^a$	Wild type (Het Amel)
$A^+ \cdot a^u$	Wild type (Het Ultra)
$a^a \cdot a^a$	Amelanistic
$a^a \cdot a^u$	Ultramel (single-heterozygous for Ultra/Amel)
$a^u \cdot a^u$	Ultra

Amel, aka **Amelanistic**, **Albino**, **Red Albino**.

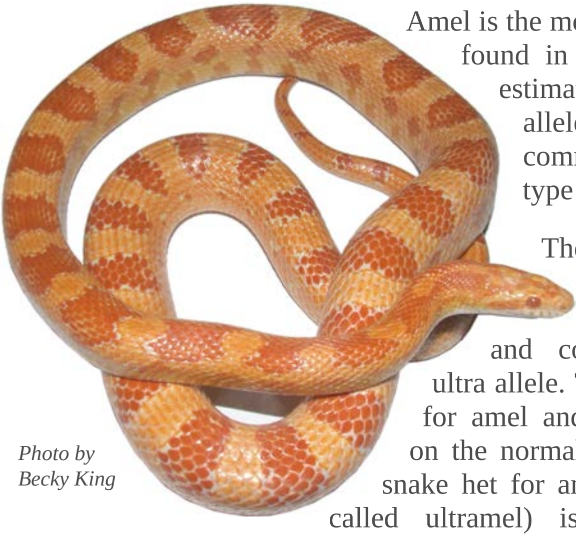


Photo by Becky King

Amel is the most common mutant found in corn snakes. It is estimated that the amel allele is slightly more common than its wild-type counterpart.

The amel gene is recessive to the wild-type allele, and codominant to the ultra allele. That is, a snake het for amel and normal will take on the normal phenotype, and a snake het for amel and ultra (also called ultramel) is an intermediate between the ultra and amel phenotypes.

As its name suggests, when amelanism is expressed, melanin (the black/brown/gray pigment) is absent. Areas where black would normally appear will instead be white, yellow, pink, or even "greenish" looking. Some amels hatch out with little to no color and nearly resemble snows. So far, specimens hatching like this have turned into typical-looking amels within a few sheds.

At 100X magnification, the typical dark spots are not visible on amel corns. It can be very frustrating trying to focus.

Amels are most easily identified by their eyes. The eyes are a distinctive glowing red/pink, except for a small dark spot toward the front of the eye. If the pattern of the snake is one where belly checkers are expected, the "black" areas on the belly should instead be a clearish flesh color, or a shade of yellow/orange/red.

Selectively-bred variations of Amel:

Sunglow, "No-white Amel"

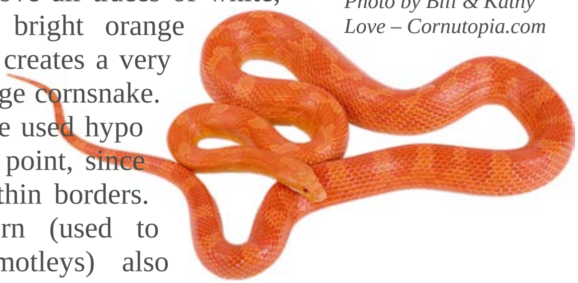


Photo by Bill & Kathy Love – Cornutopia.com

The idea is to remove all traces of white, combined with a bright orange ground color. This creates a very bright red and orange cornsnake. Some breeders have used hypo corns as a starting point, since many hypos have thin borders. The motley pattern (used to create sunglow motleys) also tends to reduce the border thickness and get rid of a lot, or all, of the white. The diffused and striped patterns have also been used to augment the sunglow look. Some sunglow offspring will start out with white borders, which will then fade out as they mature. Amelanistic cornsnakes cannot be het for this look.

Candycane

Photo by Russell Keys

The idea is to remove the oranges and yellows from the ground color, leaving red saddles on a clean white ground color with striking contrast. Any ground color is undesirable in this morph, so they tend to resemble an amel version of the silvery Miami phase normals. Candycanes are often divided into two types, red and orange. The red or orange refers to the saddle color, and **not** the ground color. A "candycane with orange ground color" would be a regular amel.

Since the yellow and orange ground color grows in as cornsnakes mature, some clean-looking candycane hatchlings can grow up to look less than ideal. It is not possible to predict with 100% accuracy which ones will do this as they grow up. But as a general rule, the hatchlings with the least amount of yellow or orange ground color, especially on the neck, will tend to grow into more ideal candycane adults. An amelanistic cornsnake cannot be het for candycane.

Reverse Okeetee, Amelanistic Okeetee, Albino Okeetee

The use of the name "Okeetee" with this morph does not imply the Okeetee *locality*, just a look. A stereotypical Okeetee corn has bold borders on bright colors. The amelanistic version still has the bright orange ground color and red saddles, but the wide black borders have been "reversed" to white. These are often bred mainly for the thickest possible white borders, with the ground color being secondary in importance. No cornsnake can be het for Okeetee, and likewise, amelanistic cornsnakes cannot be het for reverse Okeetee.

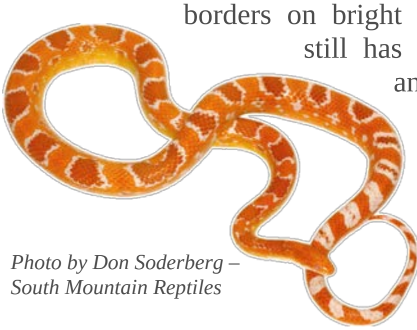


Photo by Don Soderberg – South Mountain Reptiles

Genetic Combinations with Amel:

Amel + Hypo – Hypo's effect on the coloration appears to be masked by the amel trait. Since hypo also has a mild effect on the patterning and red/orange pigments, it may affect amels, but to date nobody has presented a reliable way to visibly separate these from regular amels.

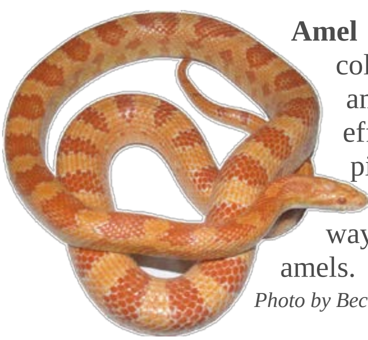


Photo by Becky King

Amel + Strawberry – Comparing the colors of amels versus strawberry amels suggests that the strawberry gene has an additional red influence on the color.

Amel + Sunkissed – Sunkissed Amels have so far displayed the expected combination of the sunkissed pattern drawn in the colors of an amel. However, only a small number of specimens exist at this time.

Amel + Lava – “Lavamels” appear to be a brightened version of amels with more of the saturated reds/oranges. It is unclear at this point how much of the difference is caused by the lava gene versus selective breeding.

Photo by Russell Keys

Amel + Anery – ***Snow*** is one of the most common double morphs. As hatchlings, saddles are pink on a white background. If saddle borders are present, they will appear “clear” and can develop yellow or mild “green” colors. As they mature, the saddle colors can fade in contrast, or turn a more pastel orange-like color. Between these and the yellows and pinks and “green” hues, snow corns can be very colorful. (*See* “Pink & Green” *snow, page 60 and* “Coral” *snow, page 49*)

Amel + Charcoal – ***Blizzard*** corns are similar to snows, but generally have a less noticeable pattern and nowhere near as much color. The saddles are a pinkish white. Hatchlings and some adults can appear virtually patternless. Yellow rings sometimes grow in around the saddles.

Amel + Caramel – As hatchlings, ***butter*** corns can somewhat resemble snows or amels. Butters can range in appearance from almost "snow-like" to almost "amel-like." Saddle colors tend to range from yellow to a dark brownish orange, and the ground color ranges from white or off-white to shades of yellow.

Photo by Sean Niland – VMS Professional Herpetoculture

Amel + Lavender – ***Opal*** corns somewhat resemble snow and blizzard corns. In some, the ground colors are more colorful than the saddles, which can be almost white, and they look like a snow corn with the colors reversed. Others can be as low contrast as blizzards. As with other lavenders, a wash of orange/pink can be present, especially in juveniles.

Photo by Sean Niland – VMS Professional Herpetoculture

Amel + Diffused – ***Fire*** corns are gaining in popularity for those who enjoy bright amelanistic corns. Several breeders are working to improve "sunglow" corns by adding bloodred lineage into the morph . Some grow up to have very little or no white flecks.

Photo by Caroline Piquette –Breeding Colors

Amel + Motley – Many of these tend to be very bright amelanistics, and are also known as "*sunglow motley*" when the ground color is a bright orange and white is absent. Candycane motleys are being bred but are less common than sunglows.

Amel + Striped – Like amel motleys, striped amels tend to be very bright in coloration. A line of sunglow stripes also exists. Candycane stripes are still unknown at this time.

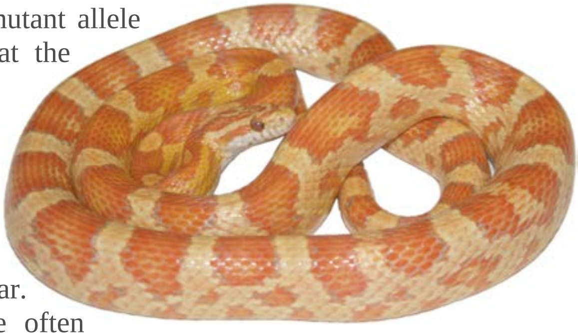
Photo by Kat Hall – Corn Quest

Amel + Cinder – The *peppermint* corn should give candycane fans a much easier way to make a red on white morph. They are still rather uncommon, but over the next few years they should give a good indication of how much red is to be expected in corns expressing the cinder trait.

Photo by Carol Huddleston –Low Belly Reptiles

Ultra and **Ultramel** *(short for "Ultra/Amel")*

Ultra is the next mutant allele to be discovered at the amel locus.



Ultras are the most extreme-looking hypo-like corns to be discovered so far. Ruby-red eyes are often apparent in ultras, and some can almost be confused with amelanistic corns. Some hatchlings also have blue or green irises. Hypermacro examination has shown that ultra and amel are codominant to each other, which means there is a difference in the phenotypes of ultras and ultramels, although in many cases it can be difficult to determine by normal means. This book treats ultra and ultramel as a single phenotype for simplicity's sake.

As adults, ultras and ultramels can become darker. The accumulation of pigment with age can also reduce or remove any ruby glow from the eyes in adults.

It should also be noted that some ultramels may be darker than some ultras, and some ultras/ultramels may resemble standard hypos, so determining genotypes with the naked eye may be less than 100% accurate.

At 100X magnification, these differences are easier to see, and it appears that it's possible to separate ultras from ultramels this way. Ultramels have nearly invisible spots. They are light enough that if you are using a lower-quality magnifier the ultramels may look like amels. Ultras have much darker spots. The border areas can be nearly transparent on ultramels, and are darker on ultras.

The origin of the ultra gene was under some scrutiny and many suspected it originated in gray rat snakes, or "white oaks phase" gray rat snakes. The hypothesis was tested by Russell Keys, who showed that a white oaks gray rat snake was not carrying the ultra gene.

Since ultra and amel are alleles, and amel is widespread in the gene pool, ultramels were quickly produced in combination with the other mutant genes.

Genetic Combinations with Ultra/Ultramel:

Ultra/Ultramel + Sunkissed – It appears that snakes with this genetic combination will resemble an ultramel in coloration, combined with the sunkissed pattern. Only a handful of them currently exist.

Photo by Hessel Duijff

Ultra/Ultramel + Anery – This morph is still somewhat new. It seems that ultramel anerys and ultramel lavenders might turn out darker than would be expected.

Photo by Sean Niland, courtesy of John Finsterwald

Ultra/Ultramel + Charcoal – The first of these were produced in 2008.

Photo by Sean Niland – VMS Professional Herpetoculture

Ultra/Ultramel+Caramel – **Golddust** corns are similar to butters except the slight amount of melanin present makes them distinguishable from butters.

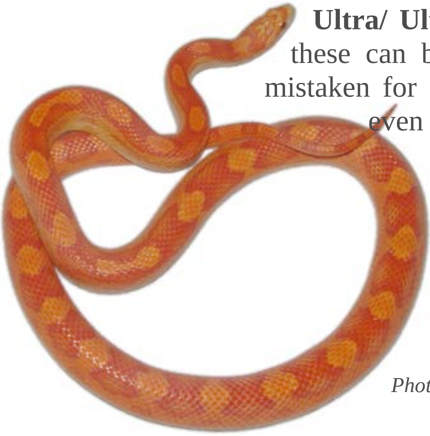
Photo by Don Soderberg – South Mountain Reptiles

Ultra/Ultramel + Lavender – These were first hatched in 2007. This morph may turn out to be darker than would have been expected from this combination of genes. The adult coloration is not yet known.

Photo by John Finsterwald

Ultra/Ultramel + Diffused – The first of these were produced in 2006.

Photo by John Finsterwald



Ultra/ Ultramel + Motley – Some of these can be so light that they can be mistaken for amelanistic corns. They may even have white flecks on the dorsal pattern. A closer look at the eyes will show that they are not amels. The motley gene, as in other morphs, tends to smooth out the colors.

Photo by Kat Hall – CornQuest

Ultra/Ultramel + Stripe – The first of these were hatched in 2007. They are expected to resemble ultramel motleys in coloration.

Photo by Stephen Wagner

The Hypo locus:

Allele	Name
H^+	Wild type
h^h	Hypomelanism
h^s	Strawberry
h^c	Christmas

Genotype	Known as:
$H^+ \cdot H^+$	Wild type
$H^+ \cdot h^h$	Wild type (Het Hypo)
$H^+ \cdot h^s$	Wild type (Het Strawberry)
$H^+ \cdot h^c$	Wild type (Het Christmas)
$h^h \cdot h^h$	Hypomelanistic
$h^h \cdot h^s$	Hypo/Strawberry
$h^h \cdot h^c$	Hypo/Christmas
$h^s \cdot h^s$	Strawberry
$h^s \cdot h^c$	Strawberry/Christmas
$h^c \cdot h^c$	Christmas

Hypo, aka **Hypomelanistic**, **Hypomel**, **Hypo A**

Hypomelanism, as its name implies, has the effect of reducing melanin.

The oranges and reds are generally washed out in comparison to normal corns, the black borders are often thinner, and the belly checkers often are bronzed. But in some cases, the darkest hypos can be darker than light-colored normals.

At 100X magnification, the dark spots on hypos are slightly less opaque than on normals, and the dendrites are typically shorter.

Hypomelanism is recessive to its wild-type allele, so only homozygous specimens express the hypo phenotype. There is some debate about this, and it seems that in certain lines the hets might be somewhat lighter than their non-het siblings.

Although this trait is generally considered a “color” it also seems to affect the pattern, by reducing the size of the melanin-producing areas. The result of this “pattern change” can be thinner border areas and a white stripe down the belly where the checkers do not fully meet. Now that many various genetic combinations involving lava and sunkissed are being produced, it appears that hypo’s effect also includes a mild hypoerythrism or fading/dulling of the reds and oranges. This is suggested by the richer colors in the lava/sunkissed versions of these combinations.

Note that the thinner borders and bronzed belly checkers are not absolute indicators of hypomelanism and visual identification of adults can be tricky. If a cornsnake has lighter/cleaner colors, thinner than normal borders, or bronzed belly checks, it is not necessarily a hypo.

The best identification is made by comparing hatchlings, where hypos are usually quite obvious compared to non-hypo siblings. Hatchlings have a lighter brown/red tone to the saddles compared to normals. Some non-hypo corns will grow up to be extremely light, making identification of adults tricky. In cases where a hypo-like adult or subadult comes from unknown sources, breeding trials and hypermacro may be the only ways to determine the type.

Some of the examples include both male and female specimens, to demonstrate the visible differences typically found between the sexes.

Selectively-bred variations of Hypos:

Crimson, Hypo Miami – The look, especially the ground color, can vary depending on the stock a given breeder started with. Some are clean gray, and others have a clean tan ground color. Hypos cannot be het for crimson or "Miami."

Photo by Carol Huddleston – Low Belly Reptiles

Genetic combinations with Hypo:

Hypo + Sunkissed – This combination creates two additive "hypo" effects, making these snakes even lighter than either type by itself. The sunkissed pattern is visible, too.

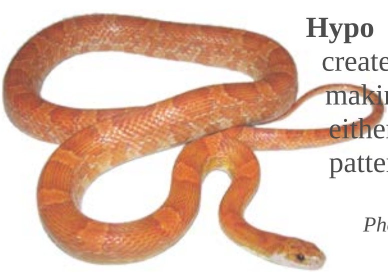


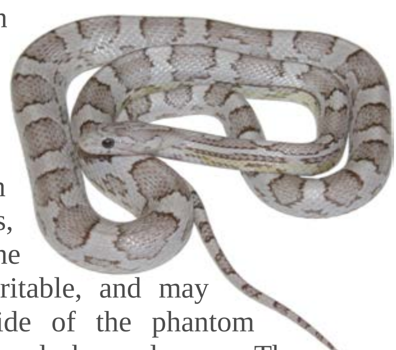
Photo by Deb Morgan

Hypo + Lava – The combination of these two genes is still very new. It remains to be seen how these two genes will interact. This specimen came from an Okeetee-like line of hypos.

Photo by Joe Pierce – CornSnakesAlive!

Hypo + Anery – **Ghost** corns are one of the most common double genetic combinations. They are a light version of anerythrism. Colors often turn to light browns, tans, and some ghosts develop "peach" and other pastel colors. Pictured are male and female.

Hypo + Charcoal – **Phantom** corns seem to be more of a niche morph than the more common ghost corns. They tend to be slightly lighter in color than ghost corns, but have less of the colorful pinks, browns, and yellows. Some phantoms will develop "purple" or "lavender" type tones, similar to what is seen in younger charcoal corns. A sub-variation of phantoms, known as Debakey phantoms, is shown below. DeBakey phantoms have a much higher contrast between ground and saddle colors, especially in the females. The DeBakey type appears to be heritable, and may express itself more subtly outside of the phantom morph, such as in normal, hypo, and charcoal corns. The exact mode of inheritance is still being tested.

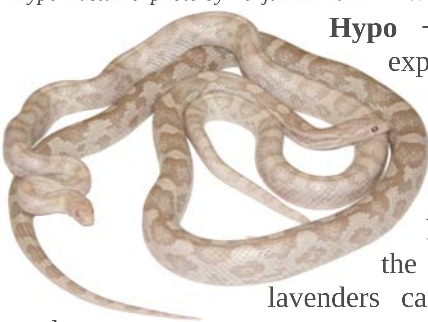


Hypo + Caramel – Amber corns have light brown saddles on a tan to yellow ground color. They are now being bred with the stripe and motley patterns.

Photo by Russell Keys

Hypo Kastanie photo by Benjamin Blum

Hypo + Kastanie – This is one of several new kastanie combinations that are expected to appear in the next few years. The appearance of this specimen suggests the two genes will interact in predictable ways.



Hypo + Lavender – Young males expressing this combination can be very colorful. Females tend to be less affected by hypo, and can be mistaken for non-hypos by beginners. Overall colors are light compared to lavenders, and the pink/orange wash in young lavenders can be even more apparent in hypos.

Hypo + Cinder – This is one of the first cinder combinations to be produced. The combination so far seems to have the expected effect, although the reds might not be as washed out by hypo as expected.

Photo by Torsten Junker – Solely Serpents

Hypo + Diffused – Most examples are out of bloodred lines and tend toward dark orange saddles on an orange ground color.

Photo by Russell Keys

Hypo + Motley –The motley trait already has its own "hypo-like" effect. Hypo adds to this to create hypo motleys even lighter than normal motleys.

Photo by Arjan Coenen – Corns.nl

Hypo + Striped – Like hypo motleys, hypo stripes are even lighter than normal motleys or stripes. This morph is often used as a shortcut to extra combinations such as striped ghost, striped amber, and striped hypo lavender.

Strawberry and Hypo/Strawberry

Breeding trials have revealed that the strawberry gene is an allele to hypo. It is codominant to hypo and recessive to wild-type. The strawberry gene causes a lightening of the snake's overall colors, but unlike hypo, it either leaves the red pigments intact or intensifies them. In certain combinations it might turn out to more or less resemble the hypo version, but so far it has been different in combination with anerythrism.

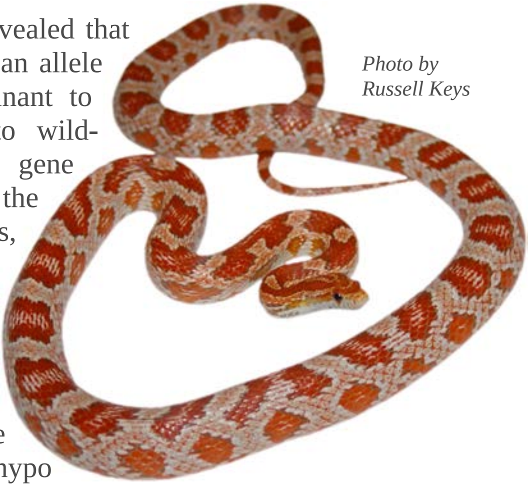
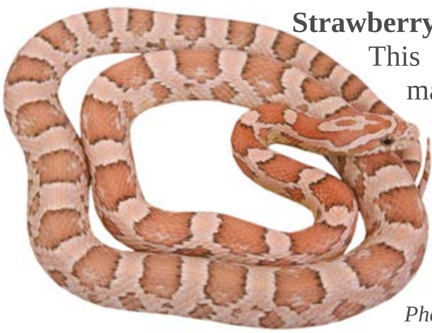


Photo by Russell Keys

At 100X strawberry corns can typically be separated from hypos. The dots are very small and nearly transparent. However it seems that these become more normal-looking when nearing a shed cycle, so keep this in mind when examining strawberry corns.

Corns heterozygous for hypo and strawberry ($h^h \cdot h^s$) tend to take on an appearance intermediate between hypos and strawberries. It might be difficult in some cases to visually identify hypo/strawberry corns with the naked eye, but at 100X the dots are not intermediate between hypo and strawberry. Instead they form a cellular mosaic: some are hypo dots, the rest are strawberry dots. The mosaic effect is especially visible after a shed. The heterozygous hypo/strawberry ($h^h \cdot h^s$) genotype could in the future gain a name, like "ultramel" is now used to specify the ultra/amel genotype, but for now they are being described as "hypo/strawberry" or "hypo/straw."

Genetic combinations with Strawberry:



Strawberry + Anery – This is believed to be the genetic makeup of "coral ghost" corns. They hatch out looking like a darker version of ghost corns, some more like anerys than ghosts, but the colors change a lot as they mature.

Photo by Connie Hurley

Strawberry + Lavender – This morph could end up resembling hypo lavenders, but using the strawberry gene will likely result in a slightly darker morph.

Photo by Marc Vervest

Strawberry + Motley –This combination does not get as light as its hypo counterpart. During some parts of the shed cycle they can resemble normal motleys more than hypos.

Strawberry + Anery + Amel –These were initially called coral snows, and thought to be hypo snows, because they produced "hypo-looking" offspring when bred to other hypos. Crossing coral snows to strawberry and hypo corns suggests that they are in fact strawberry snow corns. In the meantime, the term "coral snow" has been applied to many hypo snows, so there may be some changes in the way strawberry snows and hypo snows are described.

Hypo/Strawberry and genetic combinations:

Following are some examples of the intermediate appearances of hypo/strawberry specimens. The pinkness present in strawberry anerys seems to be intermediate in the strawberry anerys as well, although it might not be as obvious as expected in freshly hatched snakes.

Hypo/Straw

Hypo/Straw + Anery
Photo by Connie Hurley

Hypo/Straw + Motley

In the process of producing the strawberry equivalent of existing hypo combinations, the hypo/straw genotype will become mixed with other color and pattern genes in greater numbers. This should give us a more complete picture of the range of intermediates we can expect to find between these two alleles.

Christmas

Christmas corns have deep reds and dark ground colors, resembling strawberry more than hypo. Given the pink colors produced by the combination of anery with strawberry, it's possible that christmas anerys/snows could have a lot of pink tones, too. This, or something like it, might be the extra ingredient responsible for some of the mysterious pink snows such as champagne and neon corns, or the ghost-like "spectre" corns.

It has been known for some time that the christmas gene was a recessive hypo-like trait, but its relationship to other genes was until recently unknown. The results of various hypo to christmas breedings indicate that the christmas gene resides at the hypo locus. Hypermacro examinations through several shed cycles show that christmas corns are not the same as hypo or strawberry corns, meaning it is yet another mutant allele. This is a milestone in cornsnake genetics: the first locus with three known mutant alleles. There are now ten possible genotypes at the hypo locus, and it's likely that several more alleles will be found.

Christmas has been crossed with anery so far. Other combinations will start to appear over the next several years as this gene works its way into new projects. Combinations of anery-like traits with the hypo/christmas genotype and the strawberry/christmas genotype may offer another new set of ghostly morphs.

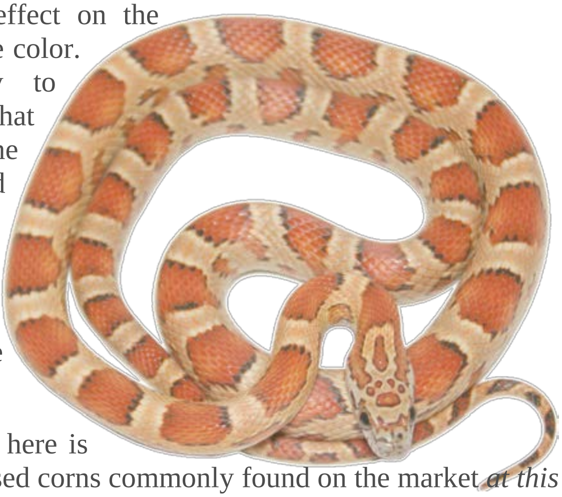
The Sunkissed locus:

Allele	Name
S^+	Wild type
s^s	Sunkissed

Genotype	Known as:
$S^+ \cdot S^+$	Wild type
$S^+ \cdot s^s$	Wild type (Het Sunkissed)
$s^s \cdot s^s$	Sunkissed

Sunkissed, Sunkissed Okeetee, "Hypo Okeetee"

At first glance, sunkissed corns might resemble hypos. Like hypo, this trait reduces melanin. However, the sunkissed gene appears to have a significant effect on the pattern as well as the color. The simplest way to describe it is to say that it increases the amount of ground area, and erodes the saddles so that they tend more toward convex shapes, rather than concave shapes.



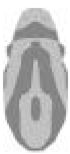
The example shown here is not typical of sunkissed corns commonly found on the market *at this time*. Since the gene originated in Okeetees, many modern sunkissed corns are in fact sunkissed Okeetees or still have a very strong Okeetee influence. More and more non-Okeetee sunkissed corns are being produced as second-generation byproducts of outcrossing them to other genetic lines, and the distinction between sunkissed and sunkissed Okeetee will become more important, so it is helpful to understand from the start that the sunkissed gene does not make a snake look like an Okeetee.

In some cases where the pattern is not as strongly affected, sunkissed might resemble hypo. In these cases, a visual ID of an otherwise unknown snake might not be 100% accurate. It is wise to ensure you know the genotypes of the parents, perform breeding trials, or use hypermacro to make a positive ID.

At 100X magnification, the spots on sunkissed corns are considerably larger and have very few if any dendrites. They are also very dark and opaque. The dots are also further apart, and as a result the border areas have small holes where the underlying flesh can be seen.

A hypothesis, proposed and being investigated through breeding trials by Connie Hurley, is that the pattern and color effects of sunkissed are separable. If this turns out to be true, sunkissed could be a very good mimic of hypo. It will likely be a few more years before such a determination can be made with any certainty but so far it seems likely. *(See page 102.)*

Normal



Sunkissed

Another distinctive characteristic of many sunkissed corns is the saddle-colored band going across the nose, which is thinned. Also common are the small dots on the nose. Note that many striped and other corns also have the thinned eye band. This is simply a result of increased ground area and reduced saddle area (via mutant genes or selective breeding) and does not mean that all snakes with thinned eye bands are sunkisseds.

The last characteristic that seems to be caused by the sunkissed gene is very strong belly checkering. In many examples the belly is more aptly described as white checkers on a black background. Sunkissed motleys have been found to possess belly checkers, and the same might hold true for sunkissed stripes and diffused sunkissed corns.

Currently, some corns labeled as “hypo Okeetee” are based on the standard hypo gene, and others on the sunkissed gene. Be sure you know which gene you are getting if you plan to breed sunkissed projects.

Selectively-bred variations of Sunkissed:

Sunkissed Okeetee – Since this gene originated within Kathy Love’s Okeetee lines, the first sunkissed corns were all Okeetees. The majority of them on the market today are more okeetee-like than not. However they are becoming less common as they are being outcrossed to other morphs, and losing Okeetee influence in the process.

Genetic combinations with Sunkissed:

Sunkissed + Lava – This combination is still quite new but appears to be what one would expect from the mixing of these two genes, with outstanding potential for bright oranges. Having Okeetee influence on both sides should help to create brilliant specimens of this morph.

Photo by Robin Teeninga – www.rrsnakes.com

Sunkissed + Anery –Several sunkissed anerys were hatched starting in 2008. So far it seems likely that they will take on similar colors to ghost corns, combined with the distinctive sunkissed pattern.

Photo by Susan Willis - Willis Wildlife Enterprises

Sunkissed + Charcoal –A handful of these currently exist. It appears they will have phantom-like colors with a sunkissed pattern. Many of these have had saddles tending toward jagged edges instead of the rounded saddles more typical of other sunkisseds.

Sunkissed + Caramel –***Honey*** corns have turned out to have higher contrast and brighter colors than ambers, probably because of their Okeetee ancestry. Several lines are now being produced, so the range of variation should become more obvious over the next few years.

Sunkissed + Lavender – It appears that ***orchid*** corns will be somewhat similar in color to hypo lavenders, but with smoother colors and lower contrast in the adults. Adult females might not be as dark as female hypo lavenders.

Sunkissed + Cinder – Many are hopeful that this specimen is a preview of this combination's pattern variations. A few breeders have hets for this combination, so more of these should appear over the next few years.

Photo courtesy of Alain Soave- Serpentolis

Photo courtesy of Alain Soave

Sunkissed + Diffused – Several of these were hatched in 2009 and more should be hatched in 2010. This specimen's pattern shows the expected interaction between the effects of the sunkissed and diffusion patterns.

Sunkissed + Motley –Instead of the connection between saddles, rounded saddles may curve somewhat toward each other, but not completely connect. Belly checkers also can appear on some sunkissed motleys, although they don't tend to be as numerous as a typical snake.

Photo by Jay & PJ Coombs - PJC Reptiles

Sunkissed + Striped –It appears these two traits will be additive and drastically reduce what little saddle color exists on the snake, making small ovals on the dorsal pattern. Several specimens of various genetic combinations have been hatched so far and all have had patterns consistent with this expectation. A more extreme expression, such as those found in terrazzo or vanishing strips could remove even more of the saddle colored markings.

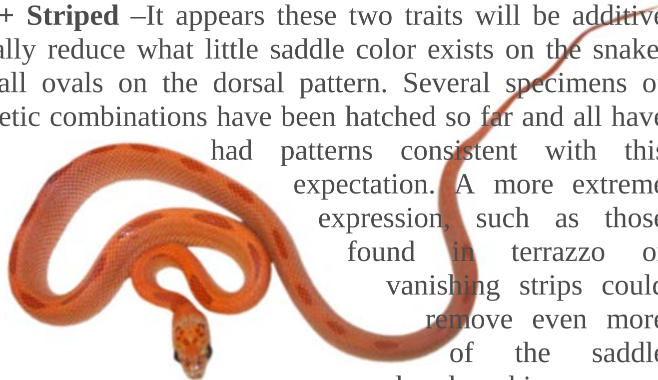


Photo by Jeff Mohr – Mohrsnakes

The Lava locus:

Allele	**Name**
V^+	Wild type
v^v	Lava

Genotype	**Known as:**
$V^+ \cdot V^+$	Wild type
$V^+ \cdot v^v$	Wild type (Het Lava)
$v^v \cdot v^v$	Lava

Lava

This is the third hypo-like trait to be discovered and is also a recessive mutant. It acts similarly to the others in that it reduces melanin and creates a brighter overall appearance. There is a mild pattern effect, with a smoothing of colors, and slight reduction in the migration of pigment toward the belly. This latter feature is most visible in the combination of lava and diffusion, many of which have outstanding diffused sides. It could have similar effects in lava motleys, too, but those are still very rare.

Hatchlings can appear almost amelanistic. The eyes have a ruby glow as a result of the extremely reduced melanin. Some specimens exhibit visible splotches of black. This is often called a “paradox lava.” Also, some specimens can have an interesting look about certain areas of scales, almost as if they have been coated in wax.

Another feature which can be seen in some hets is the reversal of the dark longitudinal lines. In these snakes they are light-colored lines instead.

Two main bloodlines of lavas exist. One is a “landrace” lava line which traces its roots back to wild corns from the Okeetee region. The other lavas have been crossed into various domesticated lines to produce genetic combinations. Pictured here is a landrace lava.

At 100X magnification, the spots on lava corns are a mosaic. Many of the dots are invisible or nearly invisible. The rest of them are found in small clusters. The typical sizes of these clusters might vary between individuals, with some snakes having small clusters, and other snakes having large clusters. It is possible that the “paradox” lavas are those with larger clusters.

It is hypothesized that the lava trait might also enhance the oranges in the ground color. The lava gene has now been outcrossed into a good number of unrelated lines in order to create hets for various genetic combinations, and future comparison of F2 and more outcrossed lavas to their siblings should shed light on the hypothesis. As it stands the vast majority of lava corns today exhibit increased orange coloration. The lava trait may include or be linked to an iridophore-affecting pattern, which could explain the presence of the white longitudinal lines, and the outstanding patterns of diffused lavas.

Genetic combinations with Lava:

Lava + Anery – A more extreme ghost-like morph is the ***Ice*** corn. Many subtle colors, such as a blue tint on the head, as well as pink undertones on the body, have been seen in this morph.

Male and female shown for color comparison. Male is the lighter/pinker specimen.

Lava + Caramel –The first of these were hatched in 2006 and dubbed ***Topaz*** corns. This specimen has ruby pupils and green irises.

Photo by Dean Arnold

Lava + Lavender –The first of these corns were hatched in 2004. It appears that these may be the most extreme version of hypo lavender. The eyes can be just as red/pink as those of amelanistic corns.

Photo by Hessel Duijff

Lava + Cinder –The first of these hatched out in 2009. Several breeders are hoping to hatch lava cinders in 2010.

Photo by Hessel Duijff

Lava + Diffused – This combination is mostly what one would expect when combining these two morphs. The lava gene also seems to intensify the diffusion pattern, for a more extreme result.

Photo by Carol Huddleston – Low Belly Reptiles

Lava + Motley –A small number of these have been hatched so far. The next few years should provide us with a better idea of what to expect of this morph. Pictured is a pin-striped lava.

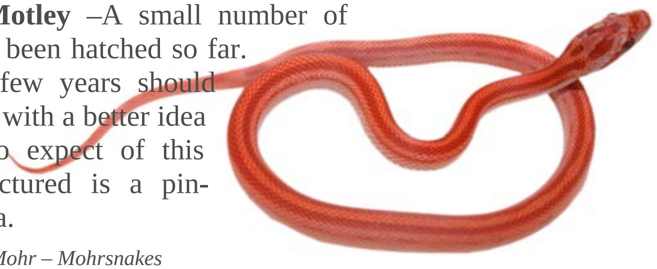


Photo by Jeff Mohr – Mohrsnakes

The Dilute locus:

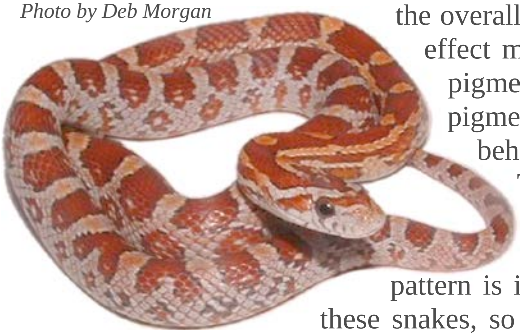
Allele	Name
Dt^+	Wild type
dt^d	Dilute

Genotype	Known as:
$Dt^+ \cdot Dt^+$	Wild type
$Dt^+ \cdot dt^d$	Wild Type (Het Dilute)
$dt^d \cdot dt^d$	Dilute

Dilute

The dilute gene is the fifth hypo-like gene found in corns. Its effects are more subtle than hypo. The dilute gene also appears to "cool" the overall coloration. The cooling effect may be due to adendritic pigment cells, causing pigment to be partially hidden behind other layers of cells. This is supported by the observation that all but a small part of the head pattern is invisible in the sheds of these snakes, so that their sheds closely resemble those of a snow or lavender corn.

Photo by Deb Morgan



Identifying a dilute specimen can be difficult for beginners. If in doubt it should be decided by breeding trials instead of visual identification of specimens from unknown heritage. Fortunately, at 100X this morph is easy to recognize. The spots are very large circles without dendrites.

Since it was originally proven in anerys, the normal phase had been unknown. Dilute has been outcrossed with several different morphs and was finally produced in normal phase (red-producing) corns in 2007. Other combinations have been produced in small numbers, such as dilute lavender and dilute caramel. New genetic combinations are expected to appear over the next few years.

Genetic combinations with Dilute:

Dilute + Anery – These snakes start with an appearance between that of anery and ghost in overall lightness. Instead of the warm browns and pastels found on anery/ghost corns, dilutes have more of a cool blue-gray appearance. Known specimens tend to accumulate pastel pinkish ground colors, especially males.


Photo by Jeff Mohr – Mohrsnakes

Dilute + Charcoal – The first of these were hatched in 2008. There are at least a few separate projects with these, so they should become well known within a few years.


Photo by Sean Niland – VMS Professional Herpetoculture

The Anery locus:

Allele	**Name**
An^{+}	Wild type
an^{a}	Anery

Genotype	**Known as:**
$An^{+} \cdot An^{+}$	Wild type
$An^{+} \cdot an^{a}$	Wild type (Het Anery)
$an^{a} \cdot an^{a}$	Anerythristic

Anerythristic, aka **Anery**, **Anery A**, **Black Albino**

*Pronounced "**An**-ur-uh-**thris**-tik," or abbreviated to "**an**-ur-ee."*

This trait takes away the red and orange coloration, leaving the snake shades of blacks, grays, and browns. The anery mutant is recessive to its wild-type allele. This is one of the most common mutants in the cornsnake population and it has been combined with nearly every other mutant.

The typical yellows on the chin/neck/belly are unaffected by anery. Although all corns have a pinkish "blush" tone on their cheeks, it tends to be much more noticeable on anerys than most other morphs.

A few red freckles may appear on the body of the snake. These usually appear after a shed, and can stay for the rest of the snake's life. Hatchlings are an attractive black and silver but the saddle colors often fade to browns, tans, or peach/pastel tones. Sexual dimorphism in anerys (and ghosts) is usually rather obvious, where males are typically more "colorful" and lighter than females.

Selectively-bred variations involving Anery:


Photo by Russell Keys

Pastel Ghost, Pastel Motley, Pastel Ghost Motley
Individual breeders use all of these terms differently. Generally it refers to softened pinkish saddles and/or ground colors on a number of different anery-based cornsnake morphs. The males tend to be more colorful and "more pastel" than the females. Some anerythristic motleys will get as light as ghosts and are sometimes referred to as "ghost motley" even though no hypomelanism is present. Some breeders will only use the term "ghost" when hypomelanism is present, and some will use the term based only on how light-looking the colors are.

It is a good idea to find out from the breeder which genetic combination is being expressed, especially whether or not hypo is being used in each combination. Until/unless a genetic influence causing the "pastel" look has been isolated and proven out, ghost corns cannot be het for "pastel."

Pink and Green Snow, Green Blotched Snow
Some snows and amelanistics can have bright yellow saddles, and show a greenish cast in the areas where the black borders exist on normal cornsnakes. Some breeders have enhanced this trait through selective breeding. These are dubbed "pink and green" snows. They are sometimes referred to as "bubblegum" snows, although a line of ratsnake hybrids is also called "bubblegum."

Genetic combinations with Anery:

Anery + Charcoal –A few specimens have been formally identified. They are intermediate between the two, with some looking more like charcoals, others looking more like anerys, and some looking like both. Pictured is a mostly intermediate example.

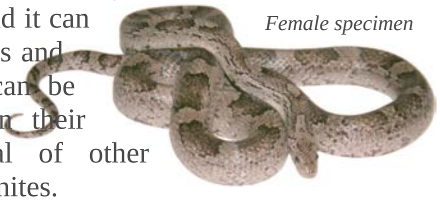
Anery + Caramel –It appears that caramel is unable to exert its yellowing influence when anery is showing. As a result, these individuals were expected to look like any other anery. However, many existing specimens have shown a tendency to stay darker and not turn brown in the saddles.

Anery + Lavender –Some cornsnakes are known homozygous for both traits, and look like typical lavenders as adults. Meanwhile other known anery lavenders take on an intermediate appearance. This might be a result of variation in iridophore density and/or distribution between each lavender corn, as well as the amount of reds the lavender gene eliminates or leaves present.

Photo by Kat Hall – CornQuest

Anery + Cinder–It appears that this combination will vary between cinder-looking and anery-looking, much like the anery + charcoal combination.

Anery + Diffused –Some male ***granite*** corns can have odd “pink” tones to their sides. This tendency appears to run in families, and it can be obvious enough that males and females in these clutches can be visually identified based on their colors. Dimorphism typical of other anerys is also apparent in granites.



Female specimen

Anery + Motley –Many of these are similar in coloration to ghost corns. As with almost all motleys, the smoothing of colors and checkerless belly are present.

Anery + Striped – These are similar in color schemes to anery motleys. Some examples of this morph can be almost patternless. A few breeders are making an effort to produce totally "patternless" cornsnakes through this and a few other morphs.

Photo by Kat Hall – CornQuest

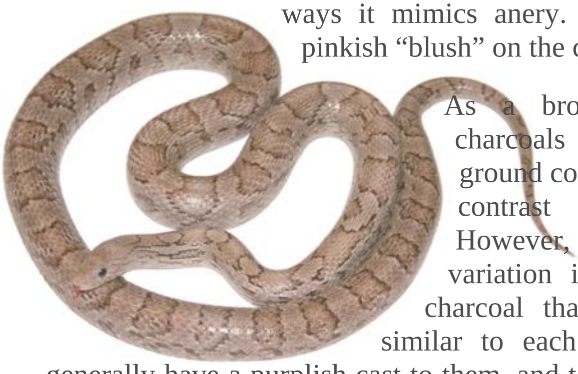
The Charcoal locus:

Allele	**Name**
Ch^+	Wild type
ch^c	Charcoal

Genotype	**Known as:**
$Ch^+ \cdot Ch^+$	Wild type
$Ch^+ \cdot ch^c$	Wild type (Het Charcoal)
$ch^c \cdot ch^c$	Charcoal

Charcoal

This was the second anery-like trait to be discovered, and in many ways it mimics anery. As in anerys, the pinkish "blush" on the cheeks stands out.



As a broad generalization, charcoals have a darker ground color and are lower in contrast than anerys. However, there is so much variation in both anery and charcoal that they often look similar to each other. Hatchlings generally have a purplish cast to them, and tend to look slightly different than anery hatchlings, enough that experienced breeders can pick them out of a crowd. Adults sometimes cannot be reliably identified by looks alone, so be sure you know which type you are getting if you plan to breed them.

Charcoal appears to alter the iridophore pattern as well. Instead of dense iridophores on the ground area and none elsewhere, the iridophores can be spread evenly across the saddle and border areas. The amount of this effect can be anywhere between mild and extreme. The variations are easily visualized in blizzard corns, where some specimens are a uniform pinkish white, and others are more like snow corns with pink saddles on a white ground. This could also be why pewters tend toward a more patternless side.

A common myth is that charcoals do not develop yellow on the chin/neck and that anerys do. Originally this was true, but this myth has been dispelled as charcoals with yellow on them, and anerys without yellow, have appeared. The appearance or absence of yellow is **not** a reliable way of determining the difference, although a trained eye can often spot differences in the *quality* of the accumulated yellow (the yellow on charcoals is lighter than that on anerys) which could be due to charcoal's effect on iridophores.

Genetic combinations with Charcoal:

Charcoal + Lava –***Diamond*** corns have been pursued for some time now, and are finally beginning to be hatched by various breeders.

Photo by Torsten Junker – Solely Serpents

Charcoal + Lavender –This combination is still very new. The overall look is a lightened charcoal, probably caused by lavender's lightening of melanins.

Photo by Sean Niland – VMS Professional Herpetoculture

Charcoal + Diffused – ***Pewter*** corns range from very dark to very light. This is a niche morph: people tend to either love pewters, or find them uninteresting or unattractive. Many of the other combinations with diffusion, such as lavender, caramel, cinder, seem to have been inspired by the pewter morph.

Charcoal + Motley –This morph is still in its infancy. It is unknown if these will resemble anery motleys, if they will take on colors similar to phantom corns, or if they will have a new look of their own.

Photo by Jeff Mohr – Mohrsnakes

Charcoal + Striped –This genetic combination was first produced in 2004. Like many striped morphs, few have been hatched and it has remained uncommon over the years.

Photo by Jeff Mohr – Mohrsnakes

The Caramel locus:

Allele	**Name**
Ca^{+}	Wild type
ca^{c}	Caramel

Genotype	**Known as:**
$Ca^{+} \cdot Ca^{+}$	Wild type
$Ca^{+} \cdot ca^{c}$	Wild type, Het Caramel
$ca^{c} \cdot ca^{c}$	Caramel

Caramel

Photo by Caroline Piquette – Breeding Colors

Caramel appears to remove the red pigmentation. Many caramels have a yellow wash over the entire body. The result is a corn in subtle shades of yellows and browns. Saddles on caramel hatchlings are brown. Some hatchlings can look very similar to anerythristic hatchlings before the yellows appear. This is not the same type of thick, dark yellow that accumulates on the neck/chin of cornsnakes. In fact, the accumulated yellows can easily be seen on caramels. Some have little or no extra yellow wash, and it is unclear whether this is simply the result of selective breeding, an influence of the caramel trait, or the result of a secondary trait.

Another way to view this trait is to see it as one that turns the red/orange pigments *into* yellow. The removal of reds acts like a recessive trait and is only expressed in homozygous specimens. Meanwhile the augmented yellow often appears in hets, usually beginning several sheds after hatching, suggesting that this part of the phenotype acts like a codominant trait. Consistent with this is the fact that the amount of yellow tends to vary in line with what would otherwise be the amount of orange on the snake's ground color. On "Miami phase" specimens, the hets can turn a particular shade of yellowish tan, versus "Okeetee phase" specimens with extreme yellow ground color.

Genetic combinations with Caramel:

Caramel + Lavender – This combination produces a snake exhibiting a mix of both traits. The lavender trait lightens the overall colors, and reduces the reds and oranges to a slight wash. The caramel trait turns the subtle orange tones into subtle yellow tinting instead.

Photo by Walter Smith

Caramel + Diffused – This combination seems to be a popular "do-it-yourself" project. It is also used as a starting point for making ***sulfur*** corns.

Caramel + Motley – As with other motley-based and stripe-based combinations, many of these tend to take on a "hypo" appearance and have lighter colors than standard caramels. Pictured is a hatchling, with only the first hint of any yellow in the ground color.

Caramel + Striped – Much like other striped combinations, these tend to take on a "hypo" appearance and have lighter colors than caramel corns. This morph is often used as a starting point for the more popular butter stripe and amber stripe morphs. *Photo by Kat Hall – CornQuest*

The Lavender locus:

Allele	Name
L^+	Wild type
l^l	Lavender

Genotype	Known as:
$L^+ \cdot L^+$	Wild type
$L^+ \cdot l^l$	Wild type (Het Lavender)
$l^l \cdot l^l$	Lavender

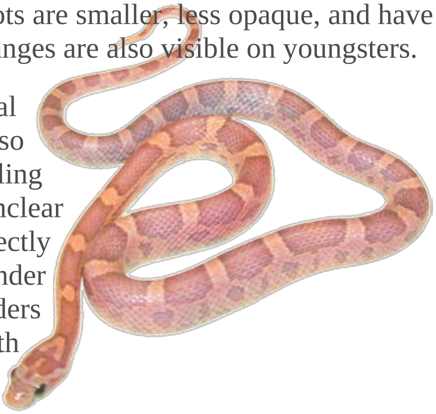
Lavender

The lavender gene is considered recessive to its wild-type allele. As adults, lavenders end up with a pattern made of dark and light shades of an odd gray color. Some retain traces of orange/pink in the ground color. Descriptions and photos are not quite enough. Lavenders must be seen in person to be appreciated or understood.

Hatchlings can appear somewhat similar to anery hatchlings but have a lighter "brown" saddle color. It seems there are two general classes of lavenders, those that are "mocha" colored and those that are more of a neutral gray. These differences could be due to iridophore distribution. As with charcoals, the iridophore pattern and density seems to vary considerably among lavender specimens. It is unknown at this time if those variations are heritable.

As juveniles, many lavenders will have an odd wash of ground color. This wash can be orangish, pinkish or purplish, and as they become adults it fades. Many lavenders will have ruby-colored eyes.

At 100X magnification, lavenders show some differences from normal and hypo corns. The spots are smaller, less opaque, and have reduced dendrites. Reds and oranges are also visible on youngsters.



Many lavenders, and normal corns from lavender lines, also have unusual patterns resembling *aztec* and *zigzag*. It is unclear whether or not this is directly related to, or linked to, the lavender trait. Normally patterned lavenders can also produce offspring with these odd patterns.

Genetic combinations with Lavender:

Lavender + Diffused – Overall darkness in ***plasma*** corns is highly variable between individuals. Some appear to resemble light-silvery pewters and others resemble dark gray pewters, but with less of the browns.

Photo by Walter Smith

Lavender + Motley – Lavender motleys have become more popular over the last several years and are becoming available and affordable. As with other lavenders, colors are highly variable between individuals.

Lavender + Striped – These are still hot items, since only a few of them exist. Several breeders are now working with them and they will likely become more common in the coming years.

Photo by Sean Niland –
VMS Professional Herpetoculture

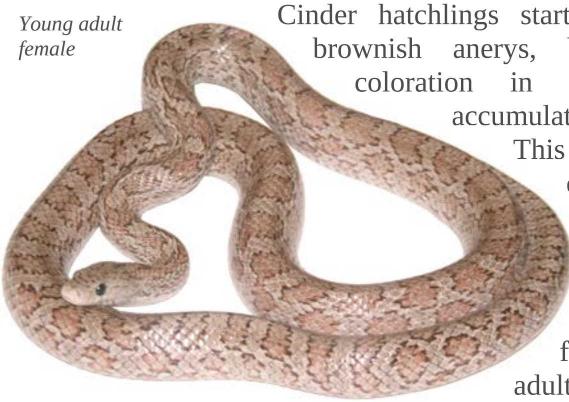
The Cinder locus:

Allele	Name
Ci^+	Wild type
ci^c	Cinder

Genotype	Known as:
$Ci^+ \cdot Ci^+$	Wild type
$Ci^+ \cdot ci^c$	Wild Type (Het Cinder)
$ci^c \cdot ci^c$	Cinder

Cinder

Young adult female

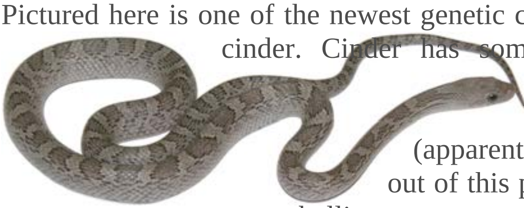


Cinder hatchlings start out looking like brownish anerys, but an odd red coloration in the saddles can accumulate as they mature. This is a different quality of red compared to other corn morphs. The accumulated "red" can then fade back out in adults. The ground color is typically a light gray, and many hets take on a miami-phase appearance. It is unknown at this time if this is caused by the cinder gene or just selective breeding within cinder lines. The effect appears to be the result of increased iridophores.

Belly pattern

An odd pattern might also be caused by this gene, showing jagged edging to the saddle shapes and high saddle counts, which are both present on the above example. More data is needed, but at this time it appears to be reliably heritable. Another variation seen in cinders is light vs dark specimens, which is not sex-linked. Breeding trials are still needed to determine if it is also heritable.

Pictured here is one of the newest genetic combinations, a diffused cinder. Cinder has some effect on the belly pattern, and it has been noted that many (apparently non-diffused) cinders out of this project have checkerless bellies.



The Kastanie locus:

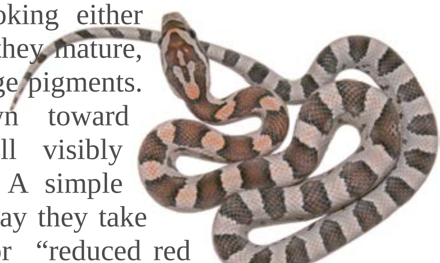
Allele	Name
K^+	Wild type
k^k	Kastanie

Genotype	Known as:
$K^+ \cdot K^+$	Wild type
$K^+ \cdot k^k$	Wild Type (Het Kastanie)
$k^k \cdot k^k$	Kastanie

Kastanie

Photo by Michael Glaß

This gene was first recognized and proven as a mendelian recessive trait in Germany. It was later discovered in the North American captive population when a "rosy blood" corn was outcrossed and the kastanie trait appeared in two of the grandchildren. Test crossing between the European and American bloodlines has shown that kastanie and "rosy" are the same.



Hatchling

Kastanie corns hatch out looking either anerythristic or nearly so. As they mature, they slowly gain red and orange pigments. Existing adults have grown toward normal colors, but are still visibly different from their siblings. A simple description of the color is to say they take on a "hypoerythristic" look, or "reduced red pigment," in the way that a hypomelanistic corn is intermediate between normal and amel.

Genetic combinations with Kastanie:

Kastanie + Amel –This combination goes by the trade name of **mandarin**.

Photo by Michael Glaß

Photo by Don Soderberg–
South Mountain Reptiles

Kastanie + Diffusion –These have been around for years under the trade name **rosy blood**, but it was recently discovered that they were using the kastanie gene. This will help speed up the process of making new combinations with kastanie since there are many existing adults to start projects.

The Buf locus:

Allele	**Name**
b^+	Wild type
B^B	Buf

Genotype	**Known as:**
$b^+ \cdot b^+$	Wild type
$b^+ \cdot B^B$	Buf (Het Wild Type)
$B^B \cdot B^B$	Buf

Buf

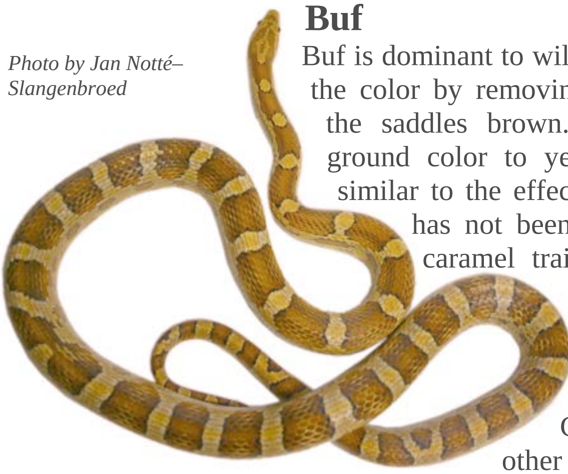


*Photo by Jan Notté–
Slangenbroed*

Buf is dominant to wild-type and modifies the color by removing the reds, leaving the saddles brown. It also turns the ground color to yellow. Overall it is similar to the effect of caramel, but it has not been as extreme as the caramel trait. It has been test bred with the caramel gene and does not act like an allele. Combinations with other colors should offer more of a glimpse into the effects of the buf gene. Buf corns het for many other genes have been produced, so new combinations should be expected to appear over the next several years.

Another morph of corns has a similar phenotype and appears to also inherit in a mendelian dominant fashion. It is currently going by the project name "oak phase" and is undergoing test breeding to verify its mode of inheritance. Pictured is a juvenile amelanistic oak phase corn. If the buf and oak phase phenotypes are similar enough, it will be nearly impossible to determine via breeding trials if the two are either alleles at the same locus, or two different genes. Crossing the two lines should indicate if it will be possible to tell the difference between the two.

Genetic combinations with Buf:

Buf + Amel –These are an orange version of amels. The buf influence can be seen when comparing these to regular amels.

Photo by Jan Notté – Slangenbroed

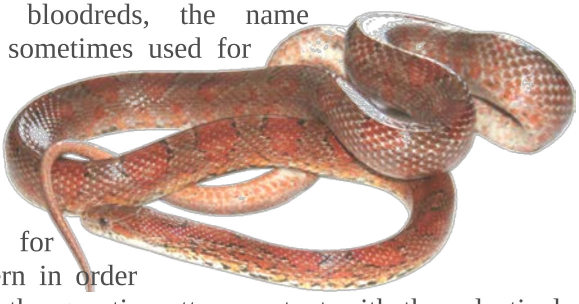
The Diffusion locus:

Allele	Name
D^+	Wild type
D^D	Diffusion

Genotype	Known as:
$D^+ \cdot D^+$	Wild type
$D^+ \cdot D^D$	Wild type
$D^D \cdot D^D$	Diffused pattern

Diffused *(Also called **Bloodred** or **Blood**)*

Since this trait originally appeared in selectively bred corns known as bloodreds, the name "bloodred" is still sometimes used for the gene.



The originators of bloodred corns have suggested using "diffused" for this gene/trait/pattern in order to avoid confusing the genetic pattern mutant with the selectively bred color morph. The Cornsnake Morph Guide uses that convention in order to clearly separate discussions of the diffusion pattern trait from the selectively bred bloodred morph.

Three main effects on the pattern are observed. The belly is wiped clear of checkers. However, some black specks or freckles can appear. The head pattern is often stretched, and the top of the head

can have a "skull" type pattern on it. The ventral scales are typically clear toward the center of the belly, which is caused by a lack or reduction of iridophores in that area. The top of the head in the more extreme hatchlings can also start out clear. In those snakes it eventually fills in with gray/white and then red or orange coloration. It is unknown at this time how much of the rest of the iridophore pattern is affected by the diffusion gene.

The pattern on the side of the body can be practically normal, or almost completely blurred out. The more diffused/blurred side patterns are usually more desirable. The diffusion pattern (like motley) often creates a mild lightening effect similar to (but not related to) hypomelanism.

Hatchlings may start out with a lot of gray on the head and ground areas, which then develops into the reds, oranges, or browns they will have as adults. In some specimens the ground color can become darker than the saddle color.

Many breeders have also observed that in full clutches of known hets, male hets will show much more of the traits than the female hets. The differences may be obvious enough to identify males and females by looking at their patterns. It's possible that this difference is either related to or a direct result of the *masque* gene.

Diffusion is a Mendelian pattern trait, but its expression can vary between individuals. It tends to act mostly like a recessive gene, but some hets may show hints or significant amounts of the diffused pattern. The amount of expression seems to be fairly consistent within each bloodline, which suggests the diffusion gene is *not* the cause. Even the most extreme-looking hets generally do not express the lateral diffusion, and they will show traces of rectangular markings on the edges of the belly. If you purchase or hatch hets for diffusion, they are likely to look normal or nearly so.

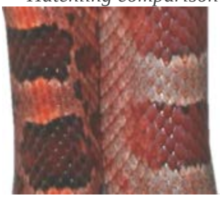
Selectively-bred variations using Diffusion:

Bloodred – This term is also used by some as the name of the diffusion gene. Selective breeding of individuals expressing the diffusion pattern trait created extremely red individuals, which were practically patternless. That was true in the beginning of bloodred corns, but varying amounts of that quality have been lost in many lines as a result of outcrossing.

"Bald" head pattern and uncheckered ventral pattern with red wash, typical of Bloodred corns

The ideal bloodred morph appears to be made of diffusion plus three additional characteristics: masque, borderlessness, and increased red pigments. The iridophore pattern may be altered too. The masque and borderless components each appear to be under the control of independent dominant genes, but breeding trials are still underway in an attempt to determine this. The increased red appears to be a selectively bred trait rather than a gene. Since there are strong genetic influences in the best specimens, some F1 offspring from "bloodred x normal" crosses can practically look like bloodreds.

Hatchling comparison



Diffused Bloodred

Typically the best bloodreds will hatch with a completely patternless gray head or with a gray "skull" type head pattern, a belly with no black checkers or specks on it, side blotches that are very smudged or even invisible, or a side pattern that is a smudge of saddle color, and very little visible "black" anywhere. The saddle color is more red than the typical brown.

As they mature, the ground color on high-quality specimens turns from gray into red. The pigment on the ground is not the typical oranges, or tans/browns, but rather the saddle color coming in where the pattern has been diffused. It can take five years for a bloodred to reach its "final" coloration but the first 1-2 years can give a good indication of the changes that will occur.

Some breeders label all diffused corns as "bloodred" regardless of the quality of their color or pattern. As a result, there are a lot of low quality specimens labeled as bloodreds. If you want the selectively bred "bloodred" morph with strong bloodred characteristics, be sure to find out from the seller if that is what they have.

Diffused Miami – Combining the diffusion pattern with the miami-phase look produces this high-contrast result. The strength of the diffused pattern will vary but might not get as extreme as the patterns of the best bloodreds.

Genetic combinations with Diffusion:

Photo by Arjan Coenen – Corns.nl

Diffused + Motley –Several potentials were hatched starting in 2006, and within the next few years, proven specimens should become more widely available.

Photo by Rich Hume – Unique Serpents

Diffused + Striped –Like diffused motleys, these should be proven through breeding trials. Proven specimens exist and are becoming more common. They are also being produced in combination with anery, amel, snow, and ghost.

The Masque locus:

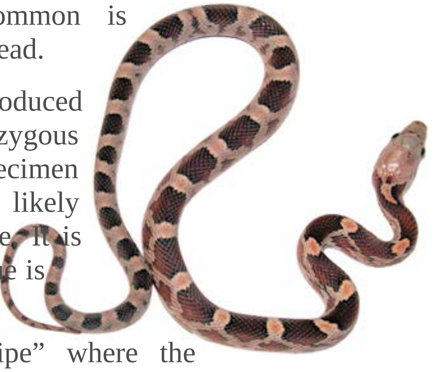
Allele	Name
Mq^+	Wild type
Mq^M	Masque

Genotype	Known as:
$Mq^+ \cdot Mq^+$	Wild type
$Mq^+ \cdot Mq^M$	Masque
$Mq^M \cdot Mq^M$	Masque

Masque

The masque gene has subtle effects on the pattern. It has been assumed for a long time that the diffusion pattern gene is codominant and that this phenotype is a result of being het for diffusion. However, breeding trials have demonstrated that masque produces the same effect when the diffusion gene is not present in either parent.

The masque gene tends to have a much more pronounced effect in males than females. As with any pattern trait it can be quite variable. The phenotype may be undetectable or go unnoticed in some females and for the sake of discussion will be treated as if it is only fully expressed in males. The overall scheme is one of expanded ground color and a very mild hypomelanistic effect. The head pattern tends toward a "skull" shape with two oval-shaped "eyes" formed by the saddle color. It can take many forms that tend to resemble ink blots. What they all have in common is expanded ground color on the head.



Test crosses so far have not produced a predictable ratio of homozygous looking males, although the specimen to the right would be a likely candidate for such a phenotype. It is assumed at this time that masque is dominant.

The belly has a "white stripe" where the checkers do not reach the center. The sides may show a slight blurring, but at this point it's possible that this characteristic is part of the existing bloodlines and not a result of the masque gene itself. The amount of head and belly expression usually go together, those with the best head patterns tend to have the best belly patterns. The most extreme belly patterns are also usually accompanied by a wash of red pigment.

It seems likely that high-end "bloodred" specimens with the most extreme patterns are actually a combination of both the masque and the diffusion morphs, which could explain why so many hets for diffusion (especially males) have this phenotype.

This is one of the more extreme examples of masque females. Typically the females have only slight stretching of the head pattern.

Genetic combinations with Masque:

The masque gene can probably be found in combination with most other genes. Since it doesn't typically have a drastic effect on the coloration or overall pattern, it is not being shown here in every combination. Following are some examples:

Masque + Hypo

Masque + Anery

Masque + Sunkissed

Pied-sided

The pied-sided pattern appears to be a secondary modifier to the diffusion trait. Instead of an allele on the already known diffusion locus, current data suggests that it acts to modify the pattern found on diffused corns. There could be a subtle phenotype associated with the pied-sided gene by itself (in the absence of diffusion) but it has not been reliably determined at this time. Results from outcrossing will eventually help to determine if it is an allele to diffusion.

Photo by Don Soderberg – South Mountain Reptiles

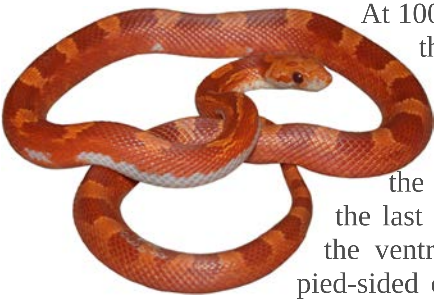
The diffusion pattern is modified in two main ways. Upon visual examination, the most obvious characteristic is the white patches that can look like the belly pattern has been extended up to the sides. In other species, if a trait is not visibly expressed when it would normally be expected to, such specimens are often called "cryptic." Since the distribution of white is random, there will be some cryptic pied-sided corns with no white scales visible, but which produce pied-sided offspring in the same ratios as any other obvious pied-sided corn. Whether these cryptic specimens are common or rare is yet to be determined, and depends on whether hobbyists and breeders use a consistent method of identification to decide whether their no-white corn is a cryptic pied-sided, or a non-pied-sided.

Pied-sided Granite photo by Torsten Junker – Solely Serpents

Pied-sideds are typically labeled and sold based on how much white is on the sides, and these different grades are sold at different prices. Terms such as high-pied, low-pied, and similar are used to describe the amount of white scales visible on the snake's pattern. The specimens with more white are priced higher.

The primary effect is a sudden "cutoff" of the patterning on the dorsal/lateral line. At this line, the pattern on pied-sided corns simply disappears and is replaced with a mixture of red, orange, and black pigments, blurring into a reddish orange coloration. There aren't any side blotches, although on some specimens there may be dark regions which look like black belly checkers on the side of the snake, as if the cells migrating to the ventral scales did not reach their destination. Some snakes also have one or two white scales on the nose. White on the tail is a reasonable possibility and might be attained through selective breeding of pied-sided corns in the future.

Hypo Pied-sided photo by Arjan Coenen – Corns.nl



At 100X the dots tend to be erratic on the sides, with each scale having a different number of dots. On other types of corns, including bloodred and diffused morphs, the dots become more dispersed on the last two or three scale rows before the ventral scutes, fading to none. On pied-sided corns, some scales are normal, some have much more dispersed dots, some have no dots at all. The white scales don't have any dots on them. This would also account for the mild hypo-like effect observed on many pied-sided corns.

A specimen from the McDonald line

Two lines of corns have been called pied-sided, they are the South Mountain Reptiles *(SMR)* line and the McDonald line. Both appear to be heritable as mendelian traits. It is still unclear at this point if the two lines are using the same gene or two different genes.

The Terrazzo locus:

Allele	Name
Tz^+	Wild type
tz^t	Terrazzo

Genotype	Known as:
$Tz^+ \cdot Tz^+$	Wild type
$Tz^+ \cdot tz^t$	Wild type (Het Terrazzo)
$tz^t \cdot tz^t$	Terrazzo

Terrazzo

Terrazzo is a recessive pattern mutant that originated in upper keys corns. Results from test breeding have shown that it is not an allele to the motley and stripe mutants in corns and it has been assigned to the Terrazzo locus with its own gene symbol. The checkerless belly pattern resembles those of motley and striped corns. Jeff Galewood has reported that the saddle colors vary throughout the range of corn saddle colors and the background color has been consistently light or gray tones so far. This coloration could be a result of natural selective breeding in the bloodlines of their ancestors.

Photo by Tim Jasinski, courtesy of Jeff Galewood JMG Reptile

The dorsal pattern tends to resemble a striped corn starting at the neck and extending for some of the snake's length, but breaks up and fades into a blur farther back on the snake. The length of the stripes varies between individuals.

Several genetic combinations have been produced in the last few years, including the amel, lava, charcoal, and caramel genes, which are pictured below. Other combinations are likely to appear as terrazzo becomes more popular in the gene pool.

Terrazzo + Amel

Photo by Tim Jasinski, courtesy of Jeff Galewood JMG Reptile

Terrazzo + Lava

Photo by Don Soderberg – South Mountain Reptiles

Terrazzo + Charcoal

Photo by Don Soderberg – South Mountain Reptiles

Terrazzo + Caramel

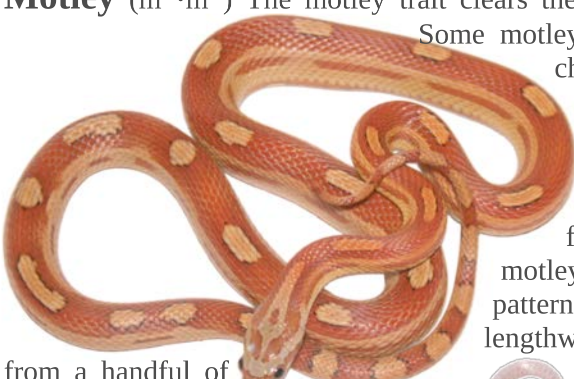
*Photo by Tim Jasinski,
courtesy of Jeff Galewood
JMG Reptile*

The Motley locus:

Allele	Name
M^+	Wild Type
m^m	Motley
m^s	Stripe

Genotype	Known as:
$M^+ \cdot M^+$	Wild type
$M^+ \cdot m^m$	Wild type (Het Motley)
$M^+ \cdot m^s$	Wild type (Het Stripe)
$m^m \cdot m^m$	Motley
$m^m \cdot m^s$	Motley, het Stripe *(motley pattern)*
$m^s \cdot m^s$	Striped (*Four-line stripe*)

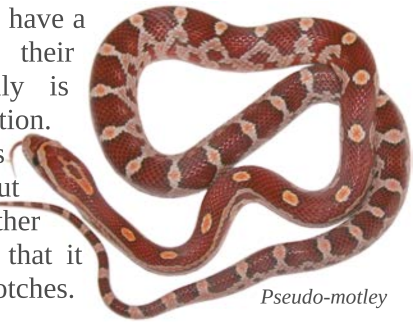
Motley ($m^m \cdot m^m$) The motley trait clears the belly of checkers. Some motleys will have a few checkers, and many will have black freckles on the belly. A wash of color can also be found in some motley corns. The dorsal pattern tends to stretch lengthwise. Anywhere from a handful of saddles to all of the saddles will be connected on the outside edges, creating circles along the back. The overall color is smoothed out and despeckled compared to non-motleys.



The side pattern can be unaffected, or it can be smeared out into dashed lines. In some cases, the side pattern is virtually nonexistant. The motley pattern also creates a lightening effect similar to (but not related to) hypomelanism. For instance, anery motleys are usually lighter than anerys, hypo motleys are generally lighter than hypos, caramel motleys are lighter than caramels, etc.

Be aware that the patterns produced by this trait are **highly** variable. This is why it was named *motley*. A wide variety of dorsal patterns can result, even in siblings from the same clutch.

Some normal (non-motley) corns have a "pseudo-motley" pattern on their necks, so examining the belly is important for proper identification. This non-motley example has very stretched dorsal saddles, but there is belly checkering. Another hint of its non-motley status is that it lacks the stretching of the side blotches.

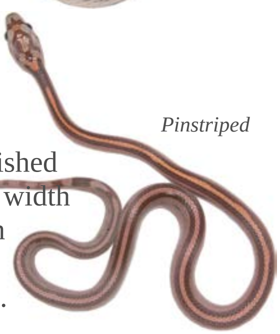

Pseudo-motley

Selectively-bred variations of Motley:

Pin-Striped and Q-tip Motleys

Some motleys have elongated saddles and intermittent stripes down the centerline, or a single pinstripe down the back. These are often referred to as "motley/stripe" or "striped motley" but problems arise with these names because it is then unclear whether the term is describing the snake's genotype (m^sm^m) or its phenotype. To avoid this situation, pin-striped and q-tipped are used to describe these variations.

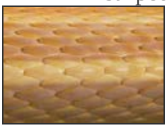

Q-tipped


Pinstriped

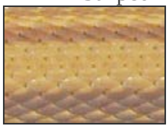
Pin-striped motleys can usually be distinguished from "true striped" corns by examining the width of the stripes. True striped corns (also known as 4-lined stripes) have a wide stripe of ground color and thin saddle stripes.

Pinstriped corns have a central stripe that is thin, or varying in width. On pinstriped corns the central stripe is usually broken on the neck. On striped corns the center stripe connects with the head pattern.

$m^m \cdot m^m$ Pinstriped



$m^s \cdot m^s$ Striped



Miami Motley

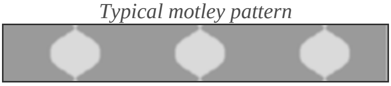
A few motley and motley/striped corns have been bred to take on the "Miami phase" look. This combines the motley pattern with a smooth silvery gray or light tan ground color. Cornsnakes cannot be het for "Miami."

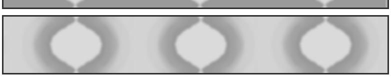
Photo by Carol Huddleston – Low Belly Reptiles

Hurricane Motley (varies widely)

This variation of the motley pattern, also sometimes called *donut* or *bullseye* motley, includes dark outlines around the circles caused by a thickening of the "border" areas, and/or fading of the central part of the saddles. In the best specimens the ground and saddles match, leaving only the circles.

Typical motley pattern





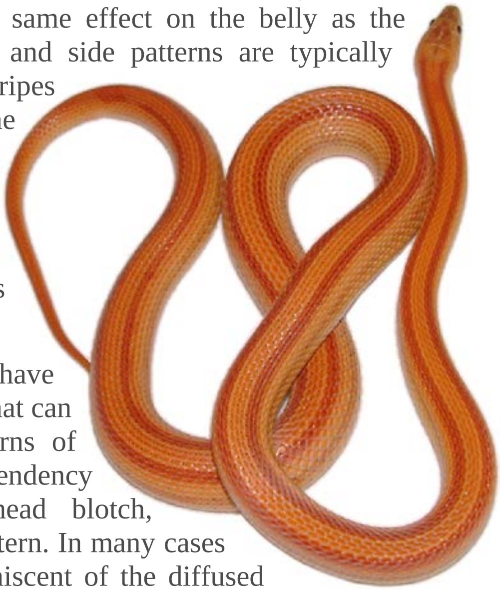
Hurricane motley pattern

Hurricane motley is found in several color morphs. They are often priced significantly higher than normal motleys of the same color, depending on the quality of the effect. Pictured is a hurricane snow motley.

*Photo by Don Soderberg–
South Mountain Reptiles*

Striped ($m^s \cdot m^s$)

Photo by Kat Hall - CornQuest



The striped trait has the same effect on the belly as the motley trait. The dorsal and side patterns are typically made of four thin stripes running the length of the body. These stripes almost always have breaks in them, especially toward the tail. Fully striped corns with no breaks are rare.

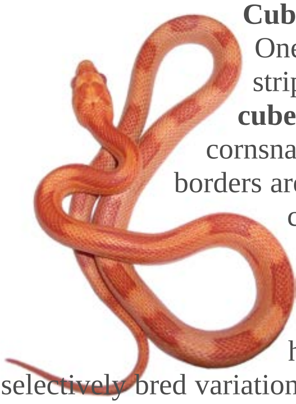
Many striped corns will have an unusual head pattern that can resemble the head patterns of bloodred corns, with a tendency toward an expanded head blotch, and/or the ringnecked pattern. In many cases a skull-like pattern reminiscent of the diffused and masque corns is visible. As with motley corns, the striped pattern lightens the overall colors.

Striped corns also lack the black borders around the saddle-colored areas. When the markings are stripes, this is less obvious, but it becomes more apparent in cubed and sunspot varieties, and can be a helpful way to tell motleys apart from stripes. The markings on stripes also include connections between the stripes, which can sometimes form other shapes, but still lack borders.

The stripe allele appears to be recessive to the motley allele. This means that a snake of the genotype $m^m \cdot m^s$ is expected to take on the pattern of a motley corn. It was previously considered codominant with motley and intermediate phenotypes were expected in any such snakes, but that model has been unreliable enough to discard. The “striped motley” (pin-striped or q-tipped) phenotype in many snakes is the result of other influences unrelated to the stripe gene. In some lines the striped gene is able to influence the head pattern and can be detected in motley/striped corns that way. Because of the above problems with terminology and identification, the ambiguous term “motley/striped” is being replaced with *pinstriped* or *q-tipped* or other similar terms in order to avoid confusion.

Selectively-bred variations of Stripe:

Photo by Terri Manning – The Snake House



Cubed

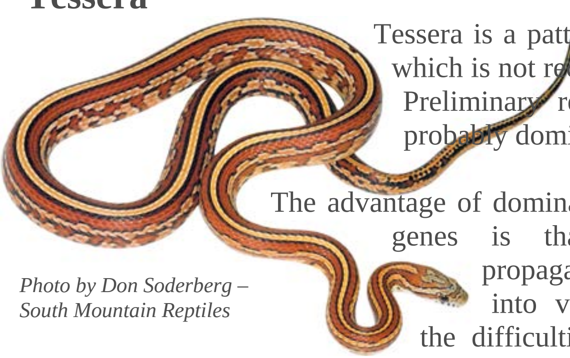
One of the odd patterns that has appeared in striped and/or motley lines is referred to as **cubed**. Genotypically, these are striped ($m^s m^s$) cornsnakes. As with other stripes, the saddle borders are completely absent. In the various types of cubes, some or all of the striping can be replaced by squares, x-shaped saddles, bowties, or ovals. Specimens with ovals are also called **sunspots**. Breeding trials have shown that the pattern is most likely a selectively bred variation of the classic striped pattern and that there is no "cube" allele at the motley locus.

Vanishing and Patternless Stripes

Other variations that have originated in striped lines are known as vanishing stripe and patternless. It appears that vanishing stripe corns are selectively bred striped corns. Patternless also appears to be related to striped corns. It is being investigated by Jeff Mohr as a potential on/off gene, and might be proven out over the next several years.

Photo by Terri Manning – The Snake House

Tessera



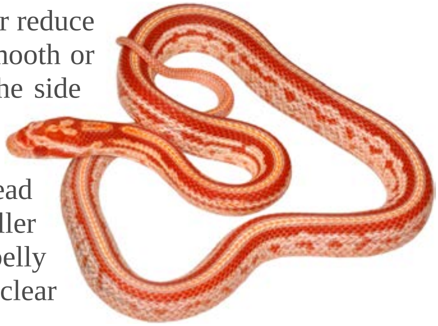
Tessera is a pattern modifying gene which is not recessive to wild type. Preliminary results suggest it is probably dominant.

Photo by Don Soderberg – South Mountain Reptiles

The advantage of dominant and codominant genes is that they can be propagated more quickly into visible morphs, and the difficulties in dealing with and testing out possible hets do not exist because heterozygotes express the mutant gene.

The tessera mutant produces a dorsal stripe, but its similarity with motley or stripe morphs ends there. In motleys and stripes, the trait's influence tends to weaken toward the tail end of the snake, and once a stripe breaks it rarely continues. On tesseras the dorsal striping does not tend to break up toward the back end of the snake. Unlike striped corns, if there are any breaks, the stripe is continued after the break.

Photo by Don Soderberg – South Mountain Reptiles



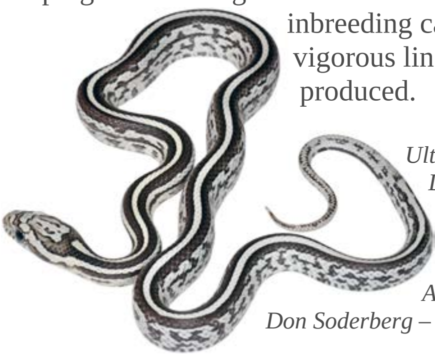
Tessera also does not remove or reduce the border areas. It does not smooth or despeckle the colors, either. The side pattern is also not smeared or missing as is expected in many motleys and stripes, instead it usually consists of smaller chunks of saddle color. The belly checkers are not always wiped clear in tesseras.

Photo by Don Soderberg – South Mountain Reptiles

There are several suspected striped and/or motley tessera corns at this time. It is unknown if the checkerless belly is a normal variation of the morph, or if it results from the motley and/or stripe genes. Pictured here is a suspected tessera motley. Note the smeared markings on the lateral pattern, typical of motley corns. The difference in stripe width between suspected striped and motley tesseras is comparable to the difference found in normal motleys and stripes.

New genetic combinations using tessera should be appearing within the next few years. Several of them, including tessera amel, tessera anery, and tessera ultramel already exist and are pictured here.

Breeding of the tessera pattern into other color and pattern morphs will be accelerated by the fact that a snake only needs to be heterozygous to express it. When crossing het parents, ¾ of the offspring will be tesseras instead of the usual ¼ that occurs with recessive genes. The ability to outcross while still knowingly keeping the tessera gene in an intended breeder means that inbreeding can be avoided, and more vigorous lines of many varieties can be produced.



Ultramel tessera (top) photo by Don Soderberg – South Mountain Reptiles

Anery tessera (bottom) photo by Don Soderberg – South Mountain Reptiles

Other Genes

Stargazer mutant:

Stargazing in corns is a neurologic condition which is caused by a simple-recessive gene. It affects the snake's ability to move correctly. At rest they appear normal, but when stimulated to move, they show uncoordinated, jerky movements with a loss of fine motor control. The more focused they are on a goal, or the more stressed, the more uncoordinated they become.

While the snake is crawling, its head may weave back and forth or even flip back, and some may even crawl upside down or backwards. Mentally, they appear to be normal, and eat, drink, eliminate, hide, and breed just like a normal corn snake. They also respond normally to stimuli such as getting excited when they smell food, or striking and fleeing when feeling threatened. They don't appear to be distressed or in any pain from the condition.

Since this gene is not dominant or codominant, it may be difficult to remove from a colony, especially without pedigrees to track the family history. Breeding trials using known carriers are needed to verify any snake as a non-carrier. Avoiding inbreeding may keep the gene from being paired up and thus expressed within the first generation, but this is only a short-term solution. Unfortunately this practice has begun and is resulting in the gene being unknowingly propagated throughout the entire corn population. In the future, even random outcrossings between different morphs will be producing stargazers. The only way to avoid propagating this (or any recessive) gene is through proving future breeders as non-carriers before their offspring are allowed to enter the gene pool. In order to do this, known carriers of the gene (also called “*S-factored*”) are needed to test suspect animals and eliminate them from the breeding program.

Test breeding and keeping pedigrees (a family tree) is the best way to clear this gene from a population, and it is also the best way to keep it from being introduced into an existing “clean” population when bringing in fresh bloodlines. Some hobbyists and breeders are working on clearing their lines, and using the American Cornsnake Registry to keep publicly-accessible records so that present and future hobbyists will have access to “gazer-free” snakes to use in their projects.

There has been a lot of internet discussion about testing for the stargazing gene, and several arguments have been put forth in an effort to justify not testing one's own stock. These are mainly based on exaggerated claims and absolutist attitudes, and have very little basis in reality. Here are some of the points you might run across followed by explanations of why they are not a good reason to avoid testing stock for stargazing.

It's only in sunkissed lines. I don't have any sunkissed corns so I don't have to worry about it.
The stargazer gene is not linked to the sunkissed gene. It has now been produced in various other morphs, and carriers have been crossed into almost every other morph.

It's too late to do anything about it.
There is plenty that can still be done. The sooner a line is tested, the less work it will be to backtrack and find other potential carriers.

You can't test every single snake, so why bother?
You also can't be sure that every egg your snakes lay will hatch, but this is not a reason to avoid breeding them. Each snake that is tested and proves clear can then be selected for use in new projects.

You can't completely eradicate it from all snakes.
This is not the goal of testing. The goal is to drastically reduce the occurrence of the gene. Testing will accomplish that goal.

You can't be absolutely 100% certain even with testing.
Absolute certainty doesn't exist anywhere. Nobody can be 100% certain that the "female" hatchlings they sell are actually females. In our experience about 5-10% of hatchlings are incorrectly sexed. While testing does not provide absolute certainty, it can provide 99% certainty, which is at least fifty times better than not testing.

Outcrossing dilutes the gene, so just keep outcrossing.
Genes cannot be 'diluted' and do not cease to exist when they are not homozygous. They continue on and eventually will be paired up unexpectedly. The frequency of any gene in the population does not decrease unless it is selected against. If you are reducing the number of stargazers hatched by yourself, without reducing the total number of stargazers to be hatched, anyone can see that this means the number of stargazers hatched by *other people* will increase by the same number you avoided hatching. In short, outcrossing doesn't solve the problem, it makes it *someone else's* problem.

Testing just spreads the gene around even more.

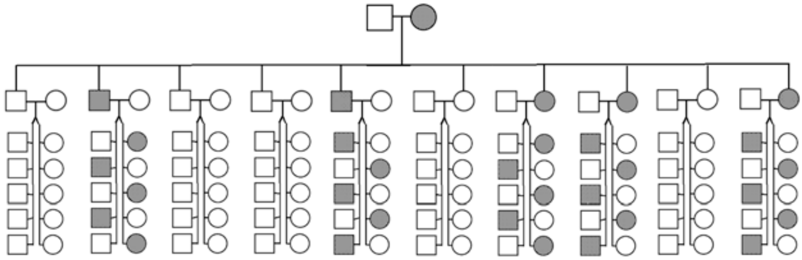
Anyone who is testing their stock because they want to improve the gene pool is also going to be conscientious enough to ensure the resulting hatchlings are not placed back into the gene pool. Any new carriers that are produced are *known* carriers and won't be used to propagate the gene into the general population.

Selling stargazers for testing only creates more demand for stargazers.

Those who have started testing their stock have all agreed not to sell any stargazers or carriers. All testing stock is being given away for free to those who need them for testing. This ensures that there is no profit in producing stargazers.

Instead of testing I'll just cull any stargazers that hatch and stop breeding the pair that produced stargazers.

By the time stargazers hatch, there have been at least two prior generations of carriers. The accompanying diagram shows the results of not testing: many new carriers will have been produced by the time a single carrier is discovered. The shaded individuals are silent carriers of the stargazer gene. Given an average of ten offspring per clutch, breeding a carrier female to only one male then ends up producing thirty carriers by the second generation. And this is assuming she is only bred the one season. It is more likely that she was bred two or more times in the other years and that there are 20+ other hatchlings with the same chance of carrying the defect.



Notice that after two generations, the parents and at least one of the grandparents, as well as dozens if not hundreds of siblings, half-siblings, aunts, uncles, cousins, and half-cousins are all possible carriers, most of which are probably owned by dozens or more other people by the time you've discovered the stargazer gene in your pair. By culling the one pair that produced stargazers (out of 112 snakes) you will only reduce the gene's frequency by one or two percent, and still will not have discovered any known non-carriers.

When you test for stargazer you have to kill all the hatchlings.
This ignores the fact that all of our snakes are raised on mice that have been bred just to be killed shortly after birth. It also ignores the fact that the number of snakes culled in testing is still smaller than the number of snakes that will be culled in the long run when the stargazer gene is found. At this time there are others who need carriers or stargazers for testing, so many of the hatchlings can be used for further testing.

There are all kinds of birth defects that happen. Should we try to test the parents of *all* defective hatchlings?
Stargazing is a *known* defect with a *known* inheritance pattern, and can be easily tested. If a birth defect appears once, it is probably not useful to test for it. But if the same birth defect seems to follow a pattern of inheritance, then a breeder probably should make an effort to determine that and remove it from the gene pool.

These snakes have never thrown stargazers so they're clear. Or, the breeder I bought them from said he has never seen any stargazers, so they are clear.
Since it is a recessive gene, an individual can carry it and pass it on to hundreds of offspring without it ever appearing. This is not a good reason to assume a snake is not a carrier. There are plenty of examples of “surprise” amels being hatched every year. This is the same inheritance pattern, but most would not consider it a pleasant surprise to hatch stargazers.

Conclusion:
We are the beneficiaries of prior generations who paved the way for us to enjoy this hobby. It is our responsibility to ensure that future generations have the same opportunities we have had to enjoy the hobby. We can leave them with a gene pool which is better than we started with, or with a defect that comes from nowhere and ruins their favorite project. Other defective genes will certainly appear in the future. We can set an example of how to cooperate and ensure they don’t damage the gene pool, or we can set an example of ignoring the problem and passing it on to the next person.

There is a lot of pressure on our hobby from lawmakers and lobbyists. Animal right activists have shut down dog shows because of genetic defects being propagated in certain dog breeds. The last thing we need is for that to be added to the list of reasons why our hobby should be outlawed.

How do I know which snakes I should test or not test?

The best way to determine this is to look through the family history of each snake and identify ancestors who are potential carriers. Talk to the person who hatched the snake, and get *specific* information about the ancestors of that snake.

The stargazer gene's history traces back through Sunkissed/Okeetee corns in the 1990's but stayed relatively isolated during that time. Starting around the year 2000, other breeders bred sunkissed (along with the stargazer gene) into various bloodlines including hypo, charcoal, lavender, bloodred, cinder, silverqueen, and several others. If your stock has a family history that goes back to around 2000 without any sunkissed or okeetee ancestors, it is a reasonably safe assumption that it is not carrying the stargazer gene. If it is a morphed corn from before 2003 there is a good chance it is also not a carrier. The most likely candidates would be those with untested sunkissed or Okeetee ancestors, and unknown ancestors.

What can I do about it?

As a breeder, there are some steps you can take to help in the effort.

- Insist on getting a family tree with any snakes you buy. A family tree needs to include *specific* snakes, not just a description of the morph or the name of the breeder who hatched it. Remember, snakes inherit genes from their parents, not their breeder.

- Provide detailed family trees with all of the hatchlings you sell. Again, this needs to include specific snakes. Be sure to include any history prior to your own if you have that information.

- Acquire testers if needed to test your stock. You can locate other breeders who have available testers on The Source at http://cccorns.com/forum in the Stargazer Discussion Forum.

- Share your results with the community, and anyone who has stock descended from yours. Communication is important.

- Do not treat stargazing like a stigma. Other responsible breeders will know that you are doing what is right for our hobby and support your efforts.

Short-tail mutant:

The phenotype produced by this gene is a shortened tail, which can look "stubby" compared to normal corns. Breeding trials have produced three generations of these snakes and shown that it is either a dominant or semidominant mutant. A short-tail X short-tail breeding trial was done in 2008, producing 15 eggs with no obvious signs of a lethal or catastrophic effect on offspring.

Affected snakes generally have some small, palpable lumps (kinked/fused vertebrae) in the tail which may or may not be visible. The gene appears to have no effect on the health or vigor of the snake. These are not highly angular kinks or corkscrews, some specimens are difficult to detect since the "lumps" can be extremely subtle or nonexistent when viewing or feeling the tail. It should be noted that none of these specimens have shown any signs of spinal deformity in the lumbar or thoracic vertebrae. This mutant has only been shown to affect the caudal vertebrae, which are in the tail, and appears to be purely cosmetic.

Radiographs (x-rays) were taken of the spines of normal and short-tail corns. The differences are shown below.

Depiction of the tail vertebrae of normal (above) and short-tail (below)

Several genes producing similar phenotypes are known in mammals including dogs, cats, and mice. In some cases these are widespread and considered to be "normal" for a particular breed.

Since this gene is not recessive, anyone wishing to remove it from their colony or avoid bringing it into their colony can simply not purchase, or not breed, any snakes showing this phenotype. It should be noted that, like all dominant and codominant genes, unaffected snakes that are siblings to short-tails, or offspring of short-tails, are **not** carrying this gene.

Additional Morphs

Counting only the possible genetic combinations, and ignoring all the selectively bred variations, there are over a million possible morphs. Following are some of the triple combinations, quad combinations, and other variations that don't quite fit the simpler classifications. Red-removal (anery, caramel, charcoal, lavender) plus black reduction (ultramel, hypo, lava, sunkissed) plus pattern alteration (motley, striped, diffused) is currently a very popular formula for creating new genetic combos. The cinders, kastanies, bufs, dilutes, terrazzos, and tesseras offer another set of branches.

+Anery
+Strawberry
+Stripe
+Selective breeding for pink/coral

Photo by Tim Jasinski, courtesy of Jeff Galewood – JMG Reptile

+Strawberry
+Anery
+Motley
+Diffusion

Photo by Connie Hurley – CCCorns

+Anery
+Hypo
+Diffusion
+Motley

Photo by Arjan Coenen – Corns.nl

+Hypo
+Charcoal
+Lavender

Photo by Connie Hurley – CCCorns

+Amelanism
+Anerythrism
+Strawberry
+Stripe
+Selective breeding for pink/coral

Photo by Tim Jasinski, courtesy of Jeff Galewood – JMG Reptile

+Amel
+Diffusion
+Motley

Photo by Charles Pritzel – CCCorns

+Amel
+Diffusion
+Stripe

Photo by Arjan Coenen – Corns.nl

+Amel
+Sunkissed
+Caramel
+Motley

Photo by Charles Pritzel – CCCorns

+Caramel
+Diffusion
+Stripe

Photo by Rich Hume – Unique Serpents

+Hypo
+Anery
+Pied-sided

Photo by Arjan Coenen – Corns.nl

+Charcoal
+Diffusion
+Stripe

Photo by Arjan Coenen – Corns.nl

+Strawberry
+Anery
+Diffusion

Photo by Connie Hurley – CCCorns

+Hypo
+Sunkissed
+Anery

Photo by Arjan Coenen – Corns.nl

+Anery
+Amel
+Tessera

Photo by Don Soderberg – South Mountain Reptiles

+Sunkissed
+Charcoal
+Masque

Photo by Arjan Coenen – Corns.nl

+Hypomelanism
+Sunkissed
+Charcoal

Photo by Charles Pritzel – CCCorns

+Sunkissed
+Charcoal
+Diffusion

Photo by Arjan Coenen – Corns.nl

+Hypo
+Anery
+Diffusion
+Stripe

Photo by Arjan Coenen – Corns.nl

Hybrids and Intergrades

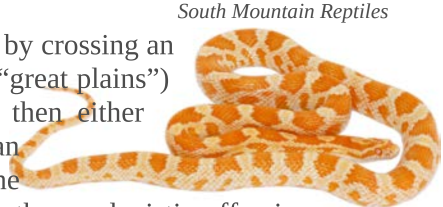
Breeding cornsnakes to many other species of North American snakes has produced hybrids and intergrades. The two most common crosses are with Emoryi ratsnakes, and California kingsnakes.

Creamsicle

This term has two meanings:

- It is generically applied to any corn/emoryi cross to denote that it carries emoryi blood.
- It is specifically applied to amelanistic corn/emoryi individuals. The pictured example is amelanistic.

Photo by Don Soderberg–South Mountain Reptiles



Creamsicle projects are started by crossing an amel cornsnake to an emoryi ("great plains") ratsnake. These offspring are then either bred to each other, or to an amelanistic cornsnake. In the second generation and beyond, the amelanistic offspring (or any amel with an emoryi ancestor) are called creamsicles.

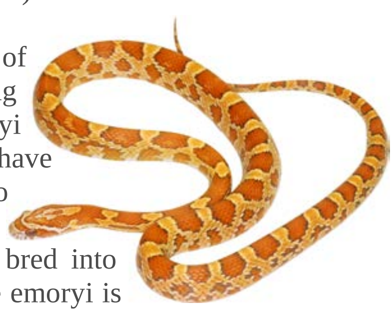


Photo by Don Soderberg–South Mountain Reptiles

The name is a great description of their colors. They can have varying amounts of cornsnake versus emoryi blood, depending on whether they have been bred back to cornsnakes or to emoryi. The colors tend more toward red as more cornsnake is bred into the lines, and more yellow as more emoryi is bred into the lines. Pictured is another variation: the ultramel creamsicle.

Rootbeer

This name has more recently caught on as a name for corn/emoryi crosses that are not expressing any genetic traits. Several other traits, including hypo and motley, have been bred into these intergrades.

Cinnamon
This name has been more frequently used to describe corn/emoryi crosses that are expressing the hypo trait. They have also been referred to as "hyposicles."

Jungle Corn

This name is applied to crosses between cornsnakes and California kingsnakes. These are **not** typically sterile, but it appears that they are not quite as fertile as either parent species. Second generation offspring (and beyond) have been produced from these hybrids. Amel, snow, motley, and other varieties of jungle corns are known to exist.

Pueblocorn

The name pueblocorn is applied to hybrid crosses between cornsnakes and pueblan milksnakes. The patterns can vary from corn to pueblan to everything between. This specimen is anerythristic and has a more pueblan-like banded pattern.

Bairdi Corn

Crosses between Baird's ratsnakes and cornsnakes have been around for a long time. There are multigenerational projects in existence. This anerythristic is a second generation hybrid.

Other crosses have been made that include milksnakes, gopher snakes, bull snakes, and other North American colubrids. Corn X Honduran crosses are known as *corndurans*. Corn X gopher crosses are referred to as *turbo corns*.

Coming Attractions

Many claims of "new" morphs are made each year. Almost all of them quickly disappear and are never heard of again.

If a "new" morph is based on a proven genetic trait, it will catch on sooner or later. The name coined by the originator/discoverer will often stick, but sometimes a different name will become more popular.

If a "new" morph is based on a selectively bred variation of an existing morph, enough people have to believe it is distinctive from existing variations that they will accept it as "new" and use the suggested name, earning it a place in the market and among hobbyists.

Some odd appearances are currently being investigated by different breeders, and could prove genetic within the next few years…

- **Unnamed mostly white mutant** – One of these is in captivity and the owner is planning to breed it to see if it is genetic. Apparently another specimen was seen in the wild in the same area. This is a good sign that the trait could be heritable. The effect seems similar to the merle/paint/splash/pied mutants in many species. If this look proves genetic it will probably generate as much excitement as the pied-sided morph did a few years ago.

- **Blushing Corns** are expected to reach the market this year. The genetic makeup is currently a trade secret.

Photo by Sean Niland – VMS Professional Herpetoculture

- **"Piebald"** – Also called *pied*, this trait replaces random patches of the snake's normal pattern with solid white. Although pied-sided has been proven as a genetic trait, a more familiar form has not yet been found in cornsnakes.

- **"Leucistic"** – A patternless white snake. This trait, like piebald, exists in many species and will inevitably show up in cornsnakes. However, leucism is also being brought into the cornsnake gene pool by hybridization with leucistic black ratsnakes and leucistic Texas ratsnakes.

- **"Wide Stripe"** – Several breeders are trying to determine the mode of inheritance of this aberrant pattern. So far it has shown it is not controlled by a simple dominant or codominant gene.

- Another similar looking aztec or wide-stripe pattern appears to be controlled by a simple codominant gene.

Photo by Jeff Mohr – Mohrsnakes

- A trait that appears to have a hypo-like and/or border reducing effect. This is commonly found in keys/rosy corns but has never been put through breeding trials. At 100X the dots are adendritic and large, resembling sunkissed. It has been seen in three generations so far, which suggests there could be a mutant gene at work in this bloodline.

- A line of striped amels that has white patches is being investigated by Tony Ignatz. The white areas increase as the snake matures. This trait appears to be genetic since several specimens in the same family show it. The other question is whether it is expressed in other morphs, or a modifier to stripes and/or amel corns.

- Various extra-red snakes are being investigated and one or more forms of this phenotype may prove to be genetic in the next few years. They are often associated with lava, bloodred, or strawberry lines and called various names such as redcoat, red factor, or high-red. It appears likely that at least one dominant extra-red gene will be found in these lines.

- Several pink lines of snows and anerys (champagnes, neons, specters, and possibly others) are potentially the result of mendelian genes. This pink is a pigment present in the scales, rather than showing through from below. Since the "coral snow" line was shown to be the result of the strawberry gene, the others may be caused by the same, or similar genes.

- **"Paradox Albino"** – Some amelanistic cornsnakes have some black areas. This is unexpected on an amelanistic cornsnake, but in some individuals it happens. Hence the name "paradox." Pictured here is a snow with black spots on it.

Photo by Sean Niland – VMS Professional Herpetoculture

- **"Java"** – This project originated in South Africa. It behaves as a simple-recessive gene and has already been combined with amel, motley, and striped. It has not yet been test-bred against other existing anery-like genes to find whether it is an allele at a known locus, or a brand new gene. The main suspicion is that it is kastanie. Pictured is a java motley.

Photo by Don Soderberg – South Mountain Reptiles

- A dark variation of sunkissed corns has been observed in two generations so far. It appears to have a mendelian component and further breeding tests to determine its mode of inheritance are in progress. It is also unknown whether it can be expressed independently of the sunkissed trait.

- This specimen is known to be hypo and charcoal but the additional genetics used to produce its look are unknown, and being investigated.

Photo by Torsten Junker – Solely Serpents

People are always searching for new traits. This is an exciting process, but problems can occur when it is assumed that all unusual appearances are caused by genetic traits. Here are some scenarios:

- An odd hatchling or hatchlings come from normal parents, and a breeder assumes it is a recessive trait and both parents are hets. The siblings not showing this "trait" are then labeled as "possible het" and sold at a premium.

- A breeder has a name applied to a line of selectively bred corns. A buyer or reseller who isn't familiar with the name then sells the individual(s) with the name attached. The next person assumes it is a genetic trait and sells offspring as "hets."

The problem is that the above scenarios are based on the assumption that anything with a name, or anything odd or unusual, is genetic. This is **not** a safe assumption, since many cornsnakes hatch out with odd patterns or colors due to any number of non-genetic causes. Unusual incubation conditions appear to be the most common cause.

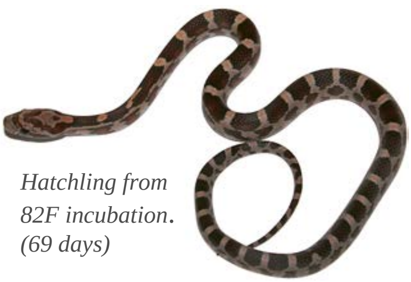
In order for a trait to be proven genetic, it must be reproducible in some predictable way. The required breeding trials can take several years from the time the first specimen is discovered. A simple rule to go by is: *without grandchildren expressing the same look, it cannot be assumed to be a simple genetic trait.* For more details see the Proving Mendelian Genes chapter.

Projects And Experiments

In past years, hobbyists have cooperated in breeding trials as well as other experiments and projects. Often, if not always, the only way to answer many questions we have is for individual hobbyists to experiment themselves and report their results. Examples of past experiments have included things like cutting the skin on thawed mice to see if digestion is improved, and supplementing with beta-carotene to see if colors are enhanced.

Cooled Incubation?

In 2009 an experiment was performed to see if incubation temperatures and times would affect colors or patterns. The test clutch was being incubated at 82F. Once a week, an egg was removed from the warm incubator and kept at 70-74F until hatching. The first egg to be cooled finally hatched on day 117. The last 3 eggs to hatch each showed an increasing amount of effect from the cooling.



Hatchling from 82F incubation. (69 days)

Another test in 2010 had similar results, but the cooled eggs did not hatch. Readers are invited to try with some of their own eggs if they wish. The experiment this time will be aimed at determining the effect on different morphs, especially patterns. The procedure is to split up a clutch when it is laid, with some the eggs incubated at normal temperatures, and the others at cooler temperatures, especially in the low 70s Fahrenheit. It's important to have both groups so that you can compare and contrast the differences made by incubation. Be sure to record the time it takes for each group to hatch. Since thermometers can vary, time is a much easier way to compare than temperatures. Based on data collected so far, the differences in color/pattern start to become

Sibling from Cool incubation. (117 days) noticeable at approximately day 90. If your clutches are hatching on day 75 or 80, they are probably still too warm to have much of an effect.

Are they codominant?

Two questions, both of which could easily be answered by a hobbyist willing to experiment, repeatedly come up. Is the hypo gene codominant? That is, can it be detected in hets using only the naked eye? The same question can be applied to the caramel gene. A simple experiment can answer both these questions. It doesn't require expertise, just time and patience. Here is how it works:
1-Breed a known het for caramel to a known non-het for caramel. (This makes all of them 50% poss hets.)
2-Raise the entire clutch.
3-At hatching, 3 months, 6 months, 1 year, and when you first breed them, look at the hatchlings with your own eyes and guess whether or not you think that individual is het. Write down your guesses.
4-Perform breeding trials on all of these individuals to find whether or not they are het for caramel.
5-Compare the actual results with your guesses and report the results to the hobbyist community.

If you were very accurate in predicting which were het and not het, and it was a sample of 10-12 or more hatchlings, this would make a very compelling argument for caramel being codominant. Other hobbyists would be able to rely on this method of identification in caramel hets, and they would often gratefully point to the results of the [your name] experiment as evidence.

Artificial Insemination

This has already been done in snakes, and at least one or two zoos have successfully bred cornsnakes through AI. Our effort will be to devise a technique hobbyists can use, which can be learned as easily as popping or probing. Hobbyists would be able to collect sperm, evaluate, store, ship, and inseminate with it. This would make cooperative breeding much easier; a single male could sire offspring from around the world. Breeding loans could be arranged without the risk or expense of shipping an adult snake. It can also help breeders with smaller colonies to avoid inbreeding.

Several techniques for collection are being investigated. The simplest is just to scoop up spilled semen at the end of a breeding. This produced a large clutch of fertile eggs in 2009 but several attempts in 2010 were unsuccessful. More data from ourselves and other hobbyists should help to establish this method and determine how effective it is on a larger scale.

Other methods involve fooling the snake into thinking it is breeding, either manually or with an “artificial vent.” A procedure known as “stripping” involves forcing the sperm through the vas deferens and collecting it at the vent.

Evaluation involves putting a sample under a microscope to check for viable sperm cells or "swimmers." This can easily be done by anyone with a $20 microscope. Swimming sperm can easily be observed at magnifications as low as 250X and 400X. This is more important for semen that has been shipped, and it is more a matter of satisfying our desire to find out as soon as possible if the sperm are viable. If they are not, you will find out about a month later when there are either slugs or no eggs.

Long term storage may prove more difficult, and although it is not absolutely necessary, it could help breeders who brumate at different times and could also allow us to breed a male long after he has died. Storage techniques will probably be the last to be perfected and may take some time.

Shipping is the second trickiest step, as sperm can be sensitive to many different conditions. However, this will be necessary for cross-collection breedings, which would be the main benefit of the AI project.

Insemination consists of detecting when the female is ovulating and then placing the sample inside her cloaca. Both of these skills are already common among hobbyists who can probe and palpate their corns, so this step may be as easy as collecting the semen.

Again, the ultimate goal of this project is to make it so easy that any hobbyist could use AI to breed their corns. If you are trying any of these things, be sure to post your methods and results on the forums at **http://cccorns.com/forum**.

American Cornsnake Registry

The ACR is an organization dedicated to helping hobbyists to create and keep pedigrees in a freely accessible online database. A pedigree is a family tree. The ACR is not like a breed club and does not try to set or enforce standards, naming conventions, or tell hobbyists what they can breed or how to label their snakes. What it does is provide an easy way for corn enthusiasts to communicate key information about their snakes, and it does so in a way that doesn't get lost when people come into and leave the hobby or when snakes change hands.

A family tree tracks ancestors through many generations, and since their genes come from their ancestors, this is extremely useful in finding out which genes, good or bad, an individual is likely to possess. This is the most important information you can have about any snake. The registry also allows you to see photos of ancestors so that more subtle tendencies can be noted when selecting which stock to purchase for a breeding project.

All of this information is accessible for free on the ACR website at **http://herpregistry.com/acr**. Anyone with internet access and a web browser can look up snakes, view their records, genotypes, photos of the snakes, and their pedigrees.

The current mentality among many hobbyists is that a snake's identity is contained in the breeder who hatched it. Most of the time snakes are simply labeled as "breeder's name stock" and nothing more. But since snakes do not inherit genes from their owners, this information says little or nothing about a snake's genetic makeup. It is an essentially useless label.

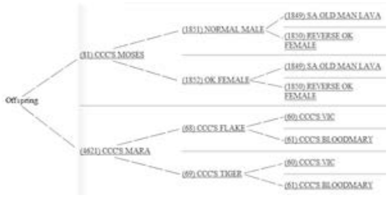
With the rampant spread of the stargazer gene through many bloodlines it is now more important than ever to know a snake's ancestors. There was a time when stargazing was only associated with the sunkissed gene, but those days are over. It is now present in caramels, charcoals, amels, anerys, motleys, and other morphs, as well as the many unmarked wild-type byproducts hatched in the process of making all of those new combinations. For each of those morphed specimens carrying the stargazer gene, there are three times as many wild-types who hatched along with them, 2/3rds of which are carriers themselves. The only way we will be able to effectively reduce the incidence of this gene is through cooperation.

The ACR is a tool which enables both hobbyists and professional breeders to cooperate by sharing information with each other. Cooperation in this way will benefit all of us much more than competing and keeping secrets from one another. It not only helps ourselves and our fellow hobbyists right now, but all future hobbyists for generations to come.

Annual memberships to the registry are now available for a flat fee. Members can then register an unlimited number of snakes during the entire calendar year, including any or all of their own hatchlings for the year. New ACR members can also use this feature to get involved and register their entire colony for one low price.

ACR Snake Registration Certificate

There are several ways to view ACR Snake Pedigrees. Some show only the ancestor's name, others show photos or more details about each individual snake.



For more information about the ACR, or to sign up as a breeder, browse breeders or snakes, or register your snakes, visit the American Cornsnake Registry's website at:

http://herpregistry.com/acr

Proving Mendelian Genes

Proving a gene as Mendelian (recessive, codominant, or dominant) is a great tool for morphing our corns and can add value to carriers of a gene, because it allows the new characteristic to be combined into the hundreds of existing morphs with predictable results. But the process can be a bit difficult to understand.

The first step is deciding if a trait or characteristic is interesting enough to try to prove it out. It can be anything you want, such as eye color, shapes of scales, speckled or smooth colors, elongated head, etc. It might also be a negative trait that people want to remove from their gene pools. If it is recessive, simply getting rid of affected individuals will only temporarily hide the problem and will make it much more difficult to deal with when it returns.

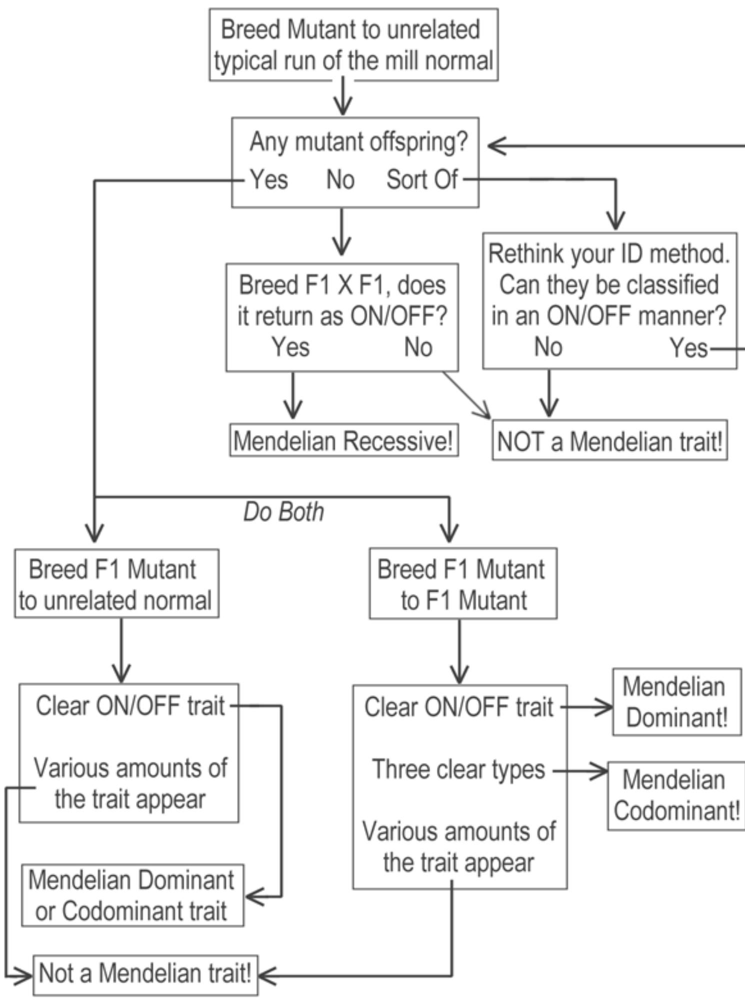
Next you need to locate a suitable mate. It is absolutely vital to choose a mate whose offspring will not mask the expression of whatever trait you are looking for, and whose offspring will not mimic the expression of that characteristic. For example, say you have found a snake with huge saddles and wish to find out if this is inherited in mendelian fashion. If you cross it to the largest-saddled snake you can find, even if the offspring have large saddles, you have no way of knowing which parent(s) contributed to that look. Conversely, if you cross it to a carrier of a patternless gene or a snake with unusually small saddles, you won't be able to tell if the saddles have been affected.

The ideal mate is a run of the mill, typical snake, or one that is expressing pattern or color genes which won't interfere with your ability to classify your hatchlings. For example, testing the motley gene can be done by crossing to a normal, a snow, a lavender, a butter, a phantom, or most other color morphs.

Once a suitable mate has been selected, you are ready to begin breeding trials. Know beforehand that you will need to produce grandchildren in order to prove an inheritance pattern. Use the following flow chart to work out your results.

When evaluating mutant or non-mutant, there should be little or no "between" states. The difference should be a very clear and easily-classified yes or no. For example, if you tried to identify motleys by counting the number of connected saddles, the results would not be very clear and you might think it is a selectively bred trait. Meanwhile if you instead use the obvious yes/no belly pattern as the indicator, you can discover its mendelian recessive mode of inheritance quite easily.

Keep this in mind, and the possibility that what you consider "a trait" could be a complex of independent traits. You might need to rethink how you identify mutant versus non-mutant. This is most common in new wild-caught specimens, and can cause confusion when the breeder hangs on to the idea that the entire look of the snake is "a trait."



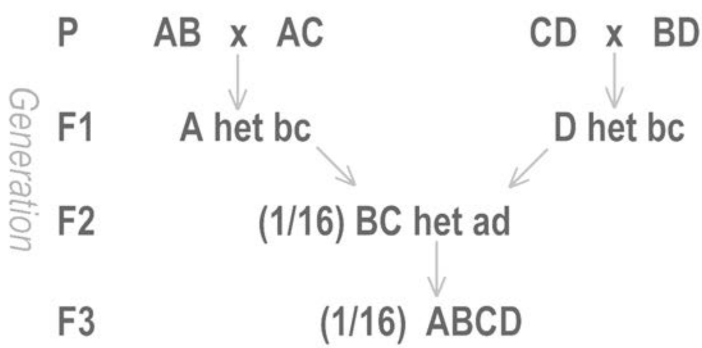
Breeding Schemes

Double and triple genetic morphs are becoming more and more common. A few quadruple morphs are being produced, too. Many times these are produced by the brute force method of producing triple or quad hets and then keeping back large quantities to overwhelm the odds. This technique can be useful if you are willing and able to keep large numbers of snakes, or if you only want to dedicate your efforts toward a single project.

Following is a method which takes advantage of the current gene pool and clutch sizes, doesn't require the keeping of such large numbers of snakes, and allows diversification of projects. It can be used as is, or as a starting point for additional schemes to roll over genes into new combinations.

Imaginary recessive genes **A** through **D** will be used for this example. Say you want to produce a snake expressing all four genes (of morph **ABCD**) but they currently only exist as single morphs and double combinations. (**AB** and **BD** and **BC**, etc)

Overview

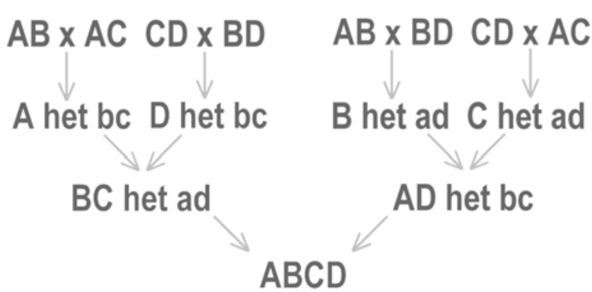


(P) Start out with double morphs. Crossing these (P) together in the right way produces (F1) snakes expressing one morph, and het for two others. Taking two separate lines of these (F1) with matching hets, you will then recover the hets while outcrossing the homos. Then you will have (F2) snakes homo for two morphs and het for two more, which you can use to produce your (F3) quad morphs.

The first advantage in this process is that you do not have to go beyond 1 in 16 odds. This is important, because it is not overly difficult or time-consuming, and does not require you to raise up and breed large numbers of snakes for a single project. You can defeat higher odds (1 in 64, for example) with larger groups, but then you end up producing many more normal and other common morphs, and you are left with less room for other projects.

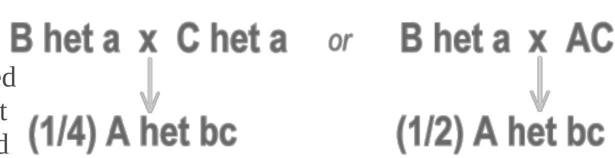
The next advantage is that this system allows you to overlap the F1 and F2 from various projects, so that you can produce even more variety by intermixing different lines. For example if you also have a project involving gene E, you might have **E het bc** to go with **A het bc**, which can be a shortcut to a project producing **ABCE** corns.

These snakes are also found in triple morph projects, for example when someone crosses a hypo lavender to a lavender motley, they produce lavenders het hypo motley. Watch for these genotypes, you might be able to find them for sale and skip the first generation.



Next, this plan can be expanded by swapping the mates from original crosses on the next year. In addition to producing **A het bc** and **D het bc**, you can also produce **C het ad** and **B het ad**. This has the advantage of producing all known hets in the final generation, where the simpler plan produces 66% possible hets.

Another potential shortcut is available if you cannot find the double morph you need to start out with. For example if you want to cross **AB** to **AC** in order to produce **A het bc**, you can also drop the overlapping gene to a het in one or both mates. Your resulting clutch will not consist entirely of the desired offspring, but you don't need an entire clutch of them.



Finally, this plan can be used cooperatively between breeders. Different people can raise up and exchange counterparts along the way. If the different breeders use different stock for their starting point, there will be no inbreeding, which can help maintain the vigor of a bloodline. Cooperation also allows again for more projects to be run simultaneously, or for more individuals to be kept as a way to increase your chances of success.

An online calculator is available on the cornguide.com website, (**http://cornguide.com/quads.php**) where you can fill in the four genes you wish to combine, check which combinations are available, and apply them to this plan.

You might find it easier to design your own such plan given what you have available to work with. When manipulating the plan, be sure to keep in mind that the advantage is gained through rolling over the double hets. The reason is that recovering Mendelian traits in this way gives a 1 in 16 chance per egg. It is reasonable to expect some success with a small number of clutches or even a single clutch. With those odds and a clutch of 16 eggs, you are about twice as likely to succeed as you are to fail.

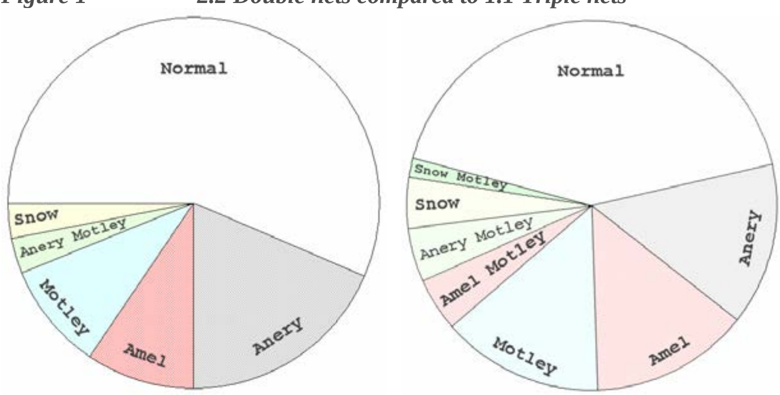
The same rollover technique works on double hets whether they are single morphed, or even double or triple morphed, as long as the double hets are the same in both mates.

Multi-hets

Since triple and other multi-hets are often overlooked or undervalued, this chapter is intended to illustrate some of their advantages.

One of the problems is that people only tend to consider the triple combination and the long odds of 1 in 64 to hatch that triple morph. But there is much more to it. The byproducts of these breedings are the real bonus of having multi-hets. They allow a breeder to produce more morphs per breedable adult snake, and more variety per breedable adult snake.

Figure 1- 2.2 Double hets compared to 1.1 Triple hets

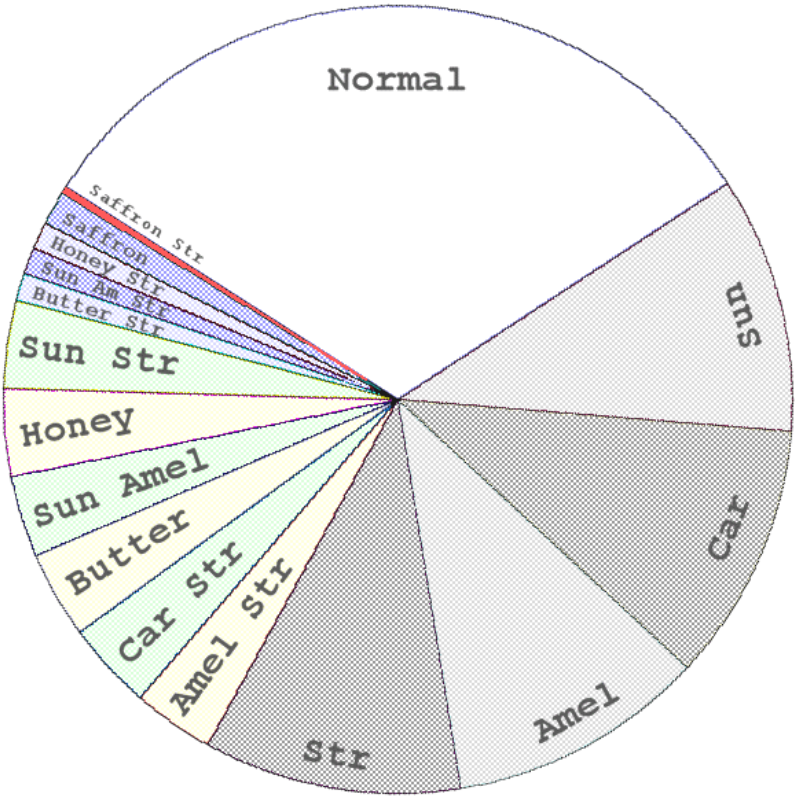


For example, say you like snow corns and anery motley corns. You could have a pair of double hets for snow and a pair of double hets for anery motley in order to produce them. Instead you could have a pair of triple hets for amel, anery, and motley taking only half as much space. If you wanted to produce the same number of eggs, you could have two pairs of the triple hets instead of one pair of each double het.

The results are far better for the triple hets. First, 25% more of the offspring are morphed instead of normal. You would also make 50% more anery motleys and snows, as well as being able to produce amel motleys and the occasional snow motley. See figure 1 for a side-by-side comparison of the results.

The advantage continues to increase with more hets. While the odds of producing a "jackpot" hatchling go down, the odds continue to improve for everything else.

Figure 2- Quad hets for sunkissed, amel, stripe, caramel



Only about a third of the hatchlings will be normals. About 4 in 10 will be single morphs. With six types of double morphs, they will be much more common, 1 in 5 instead of 1 in 16. Since there are four different triple morphs that can hatch, those "1 in 64" triple morphs are now three times as likely, 1 in 21, with quad hets.

It also allows a lot more variety using fewer snakes. It would take six pairs of double hets to be able to produce the single and double morphs shown above, with no chance of any triple or quad morphs.

Appendix A – Further Reading / Hyperlinks

A support website for this book is located at **http://cornguide.com.** A forum linked from the site allows readers to communicate with each other and the author with questions, comments, and feedback about this guide. An online genetics tutorial is there, too.

Online forums, where you can have a dialogue with other cornsnakers, and browse an ever-growing gallery of cornsnakes, are located at: **http://cccorns.com/forum**

Several handy programs (for Windows) that predict the outcomes of morph breedings exist. Three of them are on the web:
http://mywebpages.comcast.net/spencer62/cornprog.html
http://www.kornnatterlexikon.de
http://www.cornsnakes.nl/

Genetics For Herpers, by Charles Pritzel is recommended to readers of the Cornsnake Morph Guide who want to learn and understand Mendelian genetics.

The Corn Snake Manual, by Bill and Kathy Love contains a great deal of information about caring for and breeding cornsnakes, and historical information about the origins of many of the morphs, along with a lot of quality photos. It can be found at many bookstores and reptile shows, or you can order it online directly from the authors at: **http://cornutopia.com**

The second edition of the Corn Snake Manual, also by Kathy Love and Bill Love, is titled Corn Snakes The Comprehensive Owner's Guide and is also available (signed by the authors) at Kathy Love's cornutopia.com website.

Corn Snakes In Captivity by Don Soderberg was released in October of 2006 and covers everything you need to know to keep and breed your corns. It is available at **http://www.cornsnake.NET**

A Color Guide to Corn Snakes by Michael McEachern is an old but useful book. It can be found at amazon.com.

A web search for cornsnakes will bring up a lot of breeders' sites. Many of them have pictures and information about the morphs they produce and sell. This is a good way to become familiar with the names and looks and varieties. The following websites are a good starting point:

http://cccorns.com/forum is a friendly community of cornsnake enthusiasts, and has Photo and Progression Galleries as well as an entire subforum dedicated to example photos of the various morphs. *(A "progression" follows a single snake as it grows up so you can see the colors change over the years.)*

http://www.serpwidgets.com/Morphs/morphs.html

http://herpregistry.com/acr

http://cccorns.com *(collection)*

http://cornsnake.NET/ (Both the price list and the photo gallery)

http://cornutopia.com

http://vmsherp.com

http://corns.nl

http://www.morphgallery.com

http://www.iansvivarium.com/cornmorphs.html

A list of links will be maintained at http://cornguide.com.

Appendix B – Prices and Frequency of Morphs

Frequency of single and double genetic morphs:

	Amel	*Ultra*	*Hypo*	*Strawberry*	*Sunkissed*	*Lava*	*Anery*	*Charcoal*	*Caramel*	*Lavender*	*Diffused*	*Motley*	*Stripe*	*Cinder*	*Dilute*
Amel	C	U	*	r	r	r	C	C	C	C	U	C	C	r	
Ultra	U	U	r		r		r	r	U	r	r	U	r		
Hypo	*	r	C	r	U	r	C	C	C	C	U	U	U	r	
Straw	r		r	U	r		U			r	r	U			
Sun	r	r	U	r	U	r	r	r	r	r	r	r	r	r	
Lava	r		r		r	U	U	r	r	r	r	r		r	
Aner	C	r	C	U	r	U	C	*	U	U	U	C	C		U
Char	C	r	C		r	r	*	C		r	U	r	r		r
Crml	C	U	C		r	r	U		C	r	U	U	U		
Lvnd	C	r	C	r	r	r	U	r	r	C	U	U	r		
Diff	U	r	U	r	r	r	U	U	U	U	C	r	r	r	
Mot	C	U	U	U	r	r	C	r	U	U	r	C	U		
Strp	C	r	U		r		C	r	U	r	r	U	C	r	
Cind	r		r		r	r					r		r	r	
Dlt							U	r							r

Key:

	C	Common *(Easy to find and purchase)*
	U	Uncommon *(May be difficult to find and purchase)*
	r	Rare *(A handful or fewer specimens exist)*
		Not known to exist
	*	Probably common, but very few specimens identified.

***About the "Common Price Index" for morphs*:** This guide includes a "price range" for each morph. The listed prices are included to give the reader a general idea of the current market prices of different morphs. They are intended to be a "ballpark" estimate. By no means are they a suggested price, nor always the average. **In 2009 and 2010 the market prices were extremely volatile. The prices in this edition have been kept from 2010 as a guide to what they recently were, at least in proportion to other morphs.**

Note that the prices are based on hatchlings. Lone females are often sold at 10% to 25% more than the cost of a single male because breeders find it more difficult to sell off remaining unpaired males.

Adults and juveniles are usually a lot more expensive than hatchlings, since they will be able to breed sooner. Proven breeders (snakes that have already produced offspring) are even more valuable.

All cornsnakes of the same morph are **not** created equal. Variations in price are based on factors such as:

- how common they are
- how difficult they are to produce
- how popular they are
- local availability
- the quality/distinctiveness of an individual breeder's bloodline(s) compared to other bloodlines of the same morph
- being het for additional genetic traits

Many morphs can vary wildly in price, in some cases more than twice as much as others of the same morph. Trying to quote prices is like trying to predict the weather six months in advance, so take these numbers with a large grain of salt.

Finding the same morph for a lower price is not necessarily a better bargain… you tend to get what you pay for. Do not assume that any price above the listed range is overpriced. All cornsnakes are unique, and there may be a very good reason for the higher price tag. If you are getting a cornsnake with the intention of breeding it, keep in mind when considering the price tag that this snake's characteristics will influence the offspring it produces, possibly for generations to come. A few dollars difference may not be such a bargain in that light.

Prices of single and double genetic morphs:

	Amel	Ultra	Hypo	Sun	Lava	Aner	Char	Crml	Lvnd	Diff	Mot	Strp	Cind	Dlt
Amel	20-30	50-80	40-60			20-40	50-80	30-60	60-100	100-125	30-50	50-60		
Ultra	50-80	50-80				75-90		75-125			70-100			
Hypo	40-60		20-40	150-250		25-45	50-70	50-60	50-80	75-100	30-50	50-80	+++	
Sunkissed			150-250	50-75	+++	+++	+++	+++	+++		+++			
Lava				+++	70-100	125-175			+++	+++			+++	
Anery	20-40	75-90	25-45	+++	125-175	20-30		50-80	80-100	75-100	30-50	40-60		125-150
Charcoal	50-80		50-70	+++			30-40		+++	90-110				+++
Caramel	30-60	75-125	50-60	+++		50-80		20-40	+++	+++	40-60	80-100		
Lavender	60-100		50-80	+++	+++	80-100	+++	+++	50-75	125-200	75-90	+++		
Diffused	100-125		75-100		+++	75-100	90-110	+++	125-200	50-80		+++	+++	
Motley	30-50	70-100	30-50	+++		30-50		40-60	75-90		30-40	30-60		
Stripe	50-60		50-80			40-60		80-100	+++	+++	30-60	35-50		
Cinder					+++					+++			+++	
Dilute						125-150	+++							125-150

+++ *Price high and/or could vary between breeders and throughout the season.*

Prices of Other Morphs:

Triple Morphs	*Price*	*Genetic makeup:*
Avalanche	125-175	Amel Anery Diffused
Snow Motley	35-55	Amel Anery Motley
Striped Snow	50-75	Amel Anery Striped
Butter Motley	45-75	Amel Caramel Motley
Striped Butter	100-200	Amel Caramel Striped
Whiteout	200	Amel Charcoal Diffused
Hypo Snow	30-70	Amel Hypo Anery
Strawberry(Coral)Snow	95-100	Amel Anery Strawberry
Diffused Opal	+++	Amel Lavender Diffused
Opal Motley	125-175	Amel Lavender Motley
Opal Striped	+++	Amel Lavender Striped
Dilute Anery Motley	100-150	Anery Motley Dilute
Ghost Motley	40-60	Hypo Anery Motley
Pastel Motley	60-90	Ghost Motley (+selection)
Striped Ghost	50-70	Hypo Anery Striped
Hypo Granite	150-200	Hypo Anery Diffused
Hypo Pewter	150-250	Hypo Charcoal Diffused
Phantom Motley	200	Hypo Charcoal Motley
Hypo Plasma	200-300	Hypo Lavender Diffused
Hypo Lavender Motley	100-150	Hypo Lavender Motley
Striped Hypo Lavender	+++	Hypo Lavender Striped
Amberder	125	Hypo Lavender Caramel
Amber Motley	100-150	Hypo Caramel Motley
Amber Stripe	150-250	Hypo Caramel Stripe
Ultramel Anery Motley	100-150	Ultramel Anery Motley
Golddust Motley	100-150	Ultramel Caramel Motley

Corn-Emoryi hybrids	
Creamsicle	30-50
Creamsicle Motley	55-90
Creamsicle Stripe	90-100
Rootbeer	40-45
Rootbeer Motley	45-55
Rootbeer Stripe	65-80

Variations of amels	
Candycane	40-60
Reverse Okeetee	40-50
Sunglow	40-60
Cinnamon	30-45
Cinnamon Motley	40-50

Variations of normals	
Okeetee	35-70
Miami	25-40
Upper keys / Rosy Rat	25-35
Zigzag/aztec	40-70
Banded	50-80
Milksnake Phase	40-80
Kisatchie	40-60

Selectively bred submorphs	
Crimson	40-70
Hypo Miami	25-100
Miami Motley	100
Hypo Okeetee	45-55
Sunglow Motley	75-95
Pin-striped/Q-tip Motley	40-75
Bloodred	50-80

Appendix C – Glossary

Allele – Any of the variants that can occur at a given locus. See also: *gene*.

Amelanistic – A condition of having no melanin. See also: *melanin.*

Anerythristic – A condition of having no erythrin. See also: *erythrin.*

Autosomal – A locus that is found on paired chromosomes, as opposed to the sex chromosomes. Loci are assumed autosomal unless otherwise stated. See also: *Mendelian.*

Codominant – A relationship between two alleles where both are expressed when they are heterozygous together. When a codominant/codominant pair of alleles are shown in all three configurations, there are three resulting phenotypes.

Cross Multiply – A method of determining the four possible outcomes of a cross at a single locus. See also: *Punnett square, FOIL.*

Diploid – A cell that contains chromosomes in pairs. Almost all cells in an animal's body are diploid. See also: *haploid.*

Dominant – A gene that, when present in a pair, is the only one expressed. When a dominant/recessive pair of alleles are shown in all three configurations, the dominant allele completely controls the phenotype where it is present. See also: *recessive.*

Erythrin – The red pigment in cornsnakes. See also: *anerythristic.*

FOIL – A method of determining the four possible outcomes of a cross at a single locus. See also: *cross multiply, Punnett square.*

Gene – A term that can be used interchangeably with locus or allele. Its meaning depends on the context of its use. See also: *locus, allele.*

Genome – One complete set of chromosomes. An individual animal possesses a pair of genomes.

Genotype – The alleles present at a given locus or loci. See also: *phenotype.*

Haploid – A cell that only contains one genome, instead of a pair. Sperm and egg cells are haploid. See also: *Diploid.*

Het – An abbreviation for *heterozygous*.
Heterozygous – Unalike alleles at a locus. It is mutually exclusive to homozygous. See also: *homozygous.*

Homo – An abbreviation for *homozygous*.
Homozygous –Identical alleles at a locus. It is mutually exclusive to heterozygous. See also: *heterozygous.*

Hybrid – Any cross between two unrelated individuals. Most often used to describe crosses between two different species, or members of two different genuses.

Hypomelanistic – When the pigment *melanin* is reduced in quantity or quality. See also: *melanin.*

Incomplete Dominant – A type of codominance: a relationship between two alleles where both are partially expressed when they are heterozygous together. When such a pair of alleles are shown in all three configurations, there are three resulting phenotypes. See also: *codominant.*

Intergrade – 1: a cross between two species or subspecies in the wild. 2: the result of several generations of interbreeding between species or subspecies. 3: a cross between two similar species or subspecies in captivity.

Line Breeding – A type of selective breeding where related individuals are crossed in an effort to fix a trait. See also: *selective breeding.*

Locus – A location, on a particular chromosome, where a particular set of alleles reside. See also: *gene.*

Melanin – A pigment, mainly responsible for the blacks/browns on corns. See also: *amelanistic*, *hypomelanistic*.

Mendelian – A trait that follows certain expression patterns because it is controlled by a pair of genes, one inherited from each parent. See also: *autosomal*.

Phenotype – The outward appearance (size, shape, color, temperament, etc.) of a specimen. See also: *genotype*.

Possible het – A label used to designate that a specimen has a certain statistical chance of being heterozygous for a particular recessive gene.

Punnett Square – A method of determining the four possible outcomes of a cross at a single locus. The father's first gene is combined with each of the mother's genes, then the father's second gene is combined with each of the mother's genes. See also *cross multiply*, *FOIL*.

Recessive – An allele that is not expressed when paired with a dominant allele. When a dominant/recessive pair of alleles are shown in all three possible configurations, the recessive allele only controls the phenotype where it is homozygous. See also: *dominant*.

S-factored – Indicates that an individual is a proven carrier of the stargazer mutant.

Selective Breeding – A breeding program where individuals showing a certain look are bred to each other in order to enhance that look. See also: *line breeding*.

Xanthin – A pigment, mainly responsible for yellows on corns.

Zygote – A fertilized egg.

Appendix D – Morph Name Cross-Reference

A

Albino – *See Amelanistic.*
Albino Okeetee – S*ee Reverse Okeetee.*
Amel –*See Amelanistic.*
Amelanistic – Homozygous for amel at the albino locus.
Amelanistic Okeetee – *See Reverse Okeetee.*
Anery – *See Anerythristic.*
Anery A – *See Anerythristic.*
Anery B – *See Charcoal.*
Anerythristic – Homozygous for anery at the anery locus.
Avalanche – Genetic combination of amel & anery & diffused.
Aztec –Selective breeding for pattern involving aberrant angular markings.

B

Banded – Selective breeding for pattern with saddles extend toward belly.
Black Albino – *See Anerythristic.*
Blizzard – Genetic combination of amel & charcoal.
Blood – *See Bloodred.*
Bloodred–Diffused plus selective breeding for borderless and extreme red.
Bullseye – *See Hurricane Motley.*
Butter – Genetic combination of amel & caramel.

C

Candycane – Amelanistic plus selective breeding for white ground color.
Caramel – Homozygous for caramel at the caramel locus.
Charcoal– Homozygous for charcoal at the charcoal locus.
Charcoal Ghost – 1: genetic combination of anery & charcoal & hypo.
2: genetic combination of charcoal & hypo.
Christmas – Homozygous for christmas at the hypo locus.
Cinder – Homozygous for cinder at the cinder locus.
Cinnamon – Hypomelanistic plus emoryi hybrid.
Circleback Motley – Motley with saddles connecting all the way to the vent, forming circles of ground color.
Coral Snow – 1:genetic combination of amel & anery & hypo.
2: genetic combination of amel & anery, plus selective breeding for extreme coral colors.
Cornduran – Hybrid of corn and Honduran milksnake.
Creamsicle – Amelanistic plus emoryi hybrid.
Crimson – Hypomelanistic plus selective breeding.
Cubed – Striped plus variation/selective breeding for square saddles.

D

Diffused – Homozygous for diffusion at the diffused locus.
Diffused Okeetee – Diffused plus selective breeding for heavy bordering and bright orange ground color.
Donut – *See Hurricane Motley.*
Dream – Hypomelanistic plus selective breeding for Okeetee-like traits.

F

Fire – Genetic combination of amel and diffusion.
Four-lined Stripe – *See Striped.*
Frosted – 1:Selective breeding for dithering/frosting of saddle colors.
2: Denotes hybridization with gray rat snakes.

G

Ghost – Genetic combination of hypo & anery.
Ghost Motley – Genetic combination of hypo & anery & motley.
Golddust – Genetic combination of ultra/ultramel & caramel.
Granite – Genetic combination of anery & diffusion.
Green Blotched Snow – Genetic combination of amel & anery, plus variation/selective breeding for green tinted saddles.

H

Hunt Club – Denotes locality of origin as the Okeetee Hunt Club.
Hurricane Motley - Motley plus selective breeding for faded out saddle interior and boldly outlined saddles.
Hybino – Genetic combination of amel & hypo.
Hypo – *See Hypomelanistic.*
Hypo A – *See Hypomelanistic.*
Hypo Miami – Hypomelanistic plus selective breeding for Miami-phase.
Hypo Okeetee – Hypomelanistic plus selective breeding for Okeetee phase.
Hypomel – *See Hypomelanistic.*
Hypomelanistic – Homozygous for hypo at the hypo locus.
Hypo/Straw – Heterozygous for hypo and strawberry at the hypo locus.

I

Ice – Genetic combination of anery & lava.

J

Jungle – Hybrid of corn and kingsnake, usually California king.

K

Keys – *See Upper Keys.*
Kisatchie– Rat snake Species, also considered intergrade of corn x emoryi.

L

Lava – Homozygous for lava at the lava locus.
Lavamel – Genetic combination of amel & lava.
Lava Okeetee – 1: Lava descended from locality Okeetees. 2:Lava plus selective breeding for Okeetee-like traits.
Lavender – Homozygous for lavender at the lavender locus.
Locality Okeetee – Locality-specific or descended from locality stock, the locality being the Okeetee Hunt Club, or Jasper County, SC.
Look-eetee – *See Okeetee Phase.*

M

Miami – *See Miami Phase.*
Miami Motley – Motley plus selective breeding for Miami-like traits.

Miami Phase – Normal plus selective breeding for a clean light gray (non-orange/tan) ground color.
Milksnake Phase – Normal plus selective breeding for banded saddles and light ground color.
Mocha – *See Lavender.*
Motley – Homozygous for motley at the motley locus.
Motley/striped – 1: Motley plus variation/selective breeding for a pattern with pinstriped, or q-tip markings. 2: Heterozygous for motley and stripe at the motley locus.

N

No-White Amel – Amelanistic plus selective breeding for lack of white saddle areas.
Normal – 1: Not expressing any of the known genes. 2: Having normal coloration. 3: Having normal patterning.

O

Okeetee – 1: S*ee Okeetee Phase*. 2: S*ee Locality Okeetee.*
Okeetee Motley – Motley plus selective breeding for Okeetee-like traits.
Okeetee Phase - Normal plus selective breeding for Okeetee-like traits.
Opal – Genetic combination of amel & lavender.
Orange Candycane - Amelanistic plus selective breeding for white ground color and orange saddles.
Orchid – Genetic combination of sunkissed & lavender.

P

Pastel – Applied in many different ways to anerythristics of many genotypes and breeding. Please refer to individual using it.
Pastel Ghost - Applied in many different ways to anerythristics of many genotypes and breeding. Please refer to individual using it.
Pastel Motley - Applied in many different ways to anerythristics of many genotypes and breeding. Please refer to individual using it.
Patternless – Striped plus selective breeding for stripes that disappear.
Pepper – *See Pewter*.
Pewter – Genetic combination of charcoal & diffusion.
Phantom – Genetic combination of hypo & charcoal.
Pied-sided – Either genetic combination of diffusion & piedsided, or homozygous for piedsided at the diffused locus. (Breeding trials underway)
Pink and Green Snow - Genetic combination of amel & anery, plus variation/selective breeding for green tinted saddle borders, plus either pink ground color and/or pink saddle color.
Pinstriped Motley – Motley plus variation/selective breeding for pinstriping.
Plasma – Genetic combination of lavender & diffusion.
Platinum – Genetic combination of hypo, anery, & charcoal

R

Red Albino – *See Amelanistic.*

Reverse Okeetee - Amelanistic plus selective breeding for thickened border areas and extreme orange ground color.
Rootbeer – Normal plus emoryi hybrid.
Rosacea – Elpahe guttata rosacea. *See Upper Keys.*
Rosy – 1: *See Hypomelanistic.* 2: *See Upper Keys.*
Rosy Ratsnake - *See Upper Keys.*

S

Slowinskii – Pantherophis slowinskii. S*ee Kisatchie.*
Snow – Genetic combination of amel & anery.
Strawberry – Homozygous for strawberry at the hypo locus.
Stripe/Motley – *See Motley/striped.*
Striped – Homozygous for striped at the motley locus.
Striped Motley - *See Motley/striped.*
Sulfur – Genetic combination of amel & caramel & diffusion.
Sunglow – Amelanistic plus selective breeding for no borders and extreme orange ground color.
Sunglow Motley – Genetic combination of amel & motley, plus selective breeding for no borders and extreme orange ground color.
Sunkissed – Homozygous for sunkissed at the sunkissed locus.
Sunkissed Okeetee – Sunkissed plus selective breeding for Okeetee-like traits.
Sunspot – Motley or stripe plus variation/selective breeding for oval-shaped saddles.

T

Terrazzo – Homozygous Terrazzo at its locus.
Tessera – Expressing the tessera pattern. (Genetic testing in progress.)
Topaz – Genetic combination of lava & caramel.
Transparent Hypo – *See Lava.*
True Okeetee – *See Locality Okeetee.*
Turbo – Hybrid of corn and gopher snake.

U

Ultra – Homozygous for ultra at the albino locus.
Ultramel – Heterozygous for ultra and amel at the albino locus.
Upper Keys – Locality-specific, although many of these are descended out of stock from the *lower* Florida Keys.

V

Vanishing Stripe – Striped plus variation/selective breeding for striping that fades out as the snake matures.

W

Whiteout – Genetic combination of amel & charcoal & diffusion.
Wide Stripe – Unproven pattern trait, creates an aztec pattern which often consists of connected saddles forming a wide wavy dorsal stripe.
Wild-type – *See Normal.*

Z

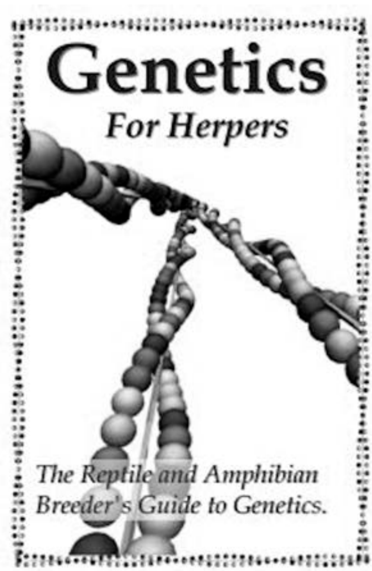
Zigzag – Variation/selective breeding for a pattern where the left/right halves of the saddles are offset, creating a zigzag.
Zipper – *See Zigzag.*

Index

Also available from Charles Pritzel:

Genetics For Herpers

Genetics For Herpers is a great way to learn what roles genetics play in breeding. For those who are new to genetics, this book is a perfect supplement to the Cornsnake Morph Guide. It starts with the basics and teaches everything you need to know. The book is 84 pages ($7^{1/2}$" x $5^{1/2}$") and includes over 120 illustrations plus a glossary. The lessons apply to all herps, so it is useful in any other species you work with.



Things you will learn:
· What genes are
· What genes do
· What happens when genes are changed
· What homozygous and heterozygous mean
· How to use and read genetic notation and symbols
· What genotypes and phenotypes mean
· What dominant, codominant, and recessive mean
· How genes are inherited
· How to predict outcomes
· What possible hets are
· How traits can mask each other

For those who want to learn more, bonus Advanced topics:
· Trait linkage
· Proving out new traits
· Proving out possible hets
· Removing undesirable genes
· Inbreeding
· Hybridization
· Sex-linked traits

http://geneticsforherpers.com

About the author:

Although his extensive cornsnake collection is his main interest, Charles Pritzel has been keeping herps of one kind or another since the late 80's. His hobby started with a wild-caught snapping turtle, and later included various small lizard and snake species.

In addition to the annual Cornsnake Morph Guide, Charles also publishes Genetics For Herpers. Along with his wife Connie Hurley, he co-owns/operates the American Cornsnake Registry and The Cornsnake Source discussion forums. He has participated in various cooperative efforts by the cornsnake community to determine the inheritance patterns of several genes including ultra, dream, masque, and strawberry.

In addition to herps, his main interest is computer programming. He is currently a stay-at-home father, author/publisher, and part-time CTP operator at the newspaper. In addition to serving in the Air Force/Air National Guard, his past jobs have included quality control engineer, software engineer, video game designer, and electronics technician.

Comments, questions, corrections, submissions, suggestions, or complaints? Come talk with us on the web at: **http://cornguide.com**

Or email the author directly: **serp@cornguide.com**

Adding to our ever - growing knowledgebase, the 2011 Edition presents an improved model for pattern formation, as well as several updates to previously known genes.

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