2022

TURKEY

COLOR GENETICS

BY FRANZ LEHNER

Turkey Color Genetics

A Brief Introduction by Franz Lehner

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Dedication

This book is dedicated to all the poultry fanciers out there. May the joy of poultry keeping accompany you for the rest of your lifes.

Introduction

Since the days of Robert Bakewell ("The Great Improver"), Charles Darwin and Georg Mendel, our understanding of selective breeding took a giant leap forward.

With this book, I want to give you a small insight into the basic rules and principles of inheritance in turkeys and encourage you to do further research.

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1 Basics of Inheritance

Inheritance is defined as the passing on of hereditary traits from one generation to another. In poultry breeding main goal is to transfer our desired traits from parents to the offspring, so understanding inheritance and principles of inheritance is the backbone of poultry breeding. Therefore, the most important principles of heredity should also be of the greatest interest to all poultry breeders.

To understand how heredity works, first, we have to look at a few basic genetics topics. Genetics is a branch of biology concerned with the study of genes and heredity. Through these genes, living organisms inherit features and traits from their ancestors.

The next few chapters will consist of a lot of technical terms, but these are mandatory to understand the principles of inheritance. So it is highly recommended to take a look at these chapters whenever you feel like you're struggling with the meaning of a term as the book continues.

By the end of this book, you will understand what causes the coloring of a turkey and how these traits will be passed on from one generation to another.

Fig. 1: Royal Palm

1.1 GENETIC INFORMATION

The basic principle of inheritance is the transmission of hereditary traits to the offspring. Hereditary factors or genes are those physiological units in which the genetic information is stored to form certain traits that regulate both the visual appearance and metabolism.

DNA is the carrier of the entire genetic information in all organisms. It is a double helical structure and located in the nucleus of every body cell. DNA is divided into individual sections (nucleotides monomers) in which the information about inherited characteristics is contained. Each section consists of a hereditary disposition. The DNA strands are located in the cell's nucleus in the form of differently sized units, called chromosomes, which contain a certain part of the genetic information in the form of genetic code. In all highly developed living beings, i.e., in almost all animals and most plants, each individual has two copies of each gene, one copy received from the father and another one from the mother.

Fig. 3: Autosome

Fig. 2: Allosome

This means that every chromosome (autosome), except for the sex chromosomes (allosome), occurs in a duplicate form. The allosomes or sex chromosomes differ from the ordinary autosomes in size, and behavior. The sex chromosome is responsible for the sex of an individual created in sexual reproduction.

The number of these chromosomes is constant within a species but varies considerably between different species.

Humans, for example, have a total of 46 chromosomes, turkeys have 82, domestic chickens have 78, and ducks have 80 chromosomes.

1.2 GERM CELLS

The germ cells are produced in the gonads, i.e. the testicles (males) and ovaries (females). The gametes are produced inside these gonads during sexual reproduction. This biological process is called gametogenesis. A gamete is a haploid that fuses with another haploid cell during fertilization. The term haploid refers to the number of sets of chromosomes found in the somatic cells being exactly half the sets of chromosomes in "diploid" cells, which have two homologous copies of each chromosome.

The process in which the gametes are formed is called Meiosis, a special type of cell division in sexually-reproducing organisms. This process involves two rounds of division that ultimately results in four cells with only one copy of each chromosome (haploid).

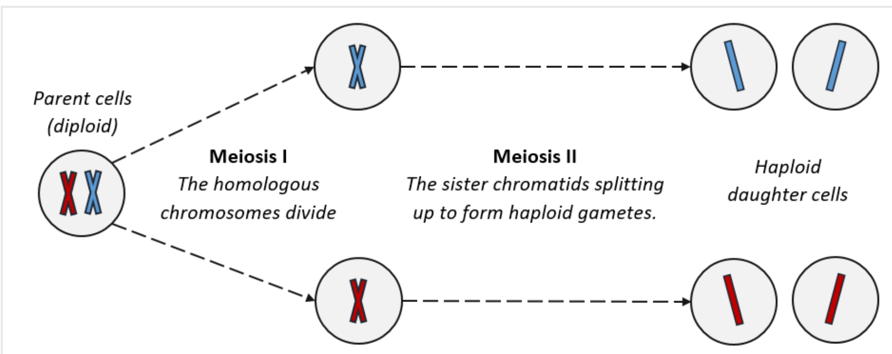


Fig. 4: Meiosis

Meiosis I: The homologous chromosomes are segregated during the first division.

Meiosis II: The sister chromatids divide again, and four haploid daughter cells (gametes) are produced.

1.3 Fertilization

Fertilization is the fusion of gametes to give rise to a new individual organism and initiate its development. In poultry, this happens either through natural insemination or artificial insemination. During the fertilization, the male sperm cell and female egg cell fuse, creating out of these haploid cells a diploid cell with a complete set of paired chromosomes again (diploid cell).

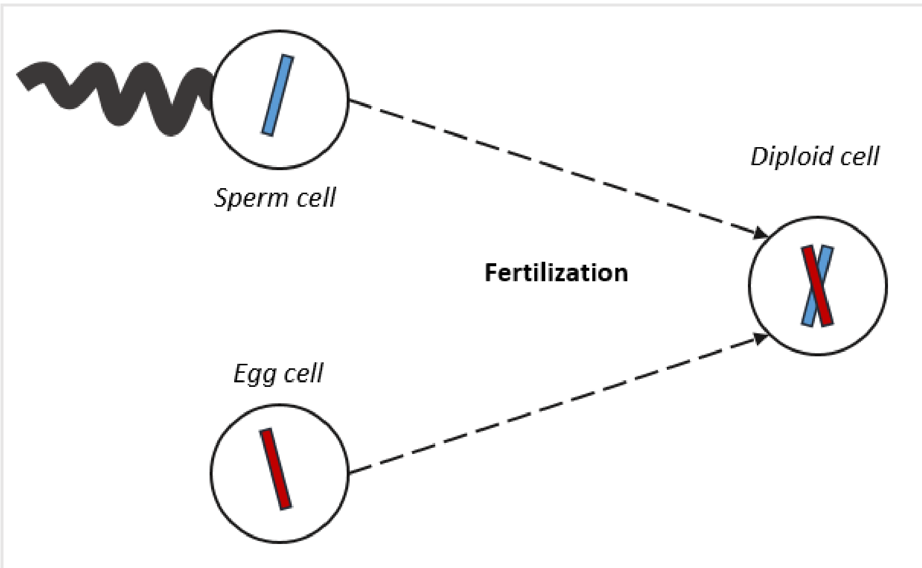


Fig. 5: Fertilization

When the sperm and egg cells fuse, the set of chromosomes become diploid again, as one half of the chromosome is contributed by the father (sperm cell) and the other by the mother (egg cell). Thus, each descendant receives half of his genetic make-up from one parent and a half from the second parent.

1.4 GENDER INHERITANCE

As previously described, organisms usually have duplicates of each chromosome. These are known as autosomes. However, there is an exception, the sex chromosomes (allosomes). They consist of a Z chromosome and a mostly smaller W chromosome and determine the gender of an animal.

In most animals, including humans, the female is characterized by two X chromosomes (XX), while the male carries the combination of one X and one Y chromosome (XY). Birds have a different system. Here the male carries two Z chromosomes (ZZ) and the female carries one W and one Z chromosome (ZW).

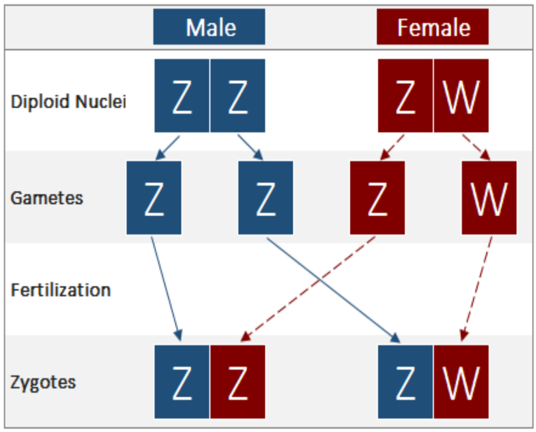


Fig. 6: Inheritance of sex chromosomes

During the germ cells' formation, the male produces Z-chromosome-bearing sperms, while the female supplies both, W and Z-chromosomes.

When a sperm and egg cell fuse, statistically half of the offspring will receive two Z chromosomes, and the other half will receive W and Z chromosomes. The sons receive a Z chromosome from the father and one from the mother, while the daughters receive their Z chromosome from the father and the W chromosome from their mother.

If the underlying genetics are located on the Z chromosome, this mechanism is responsible for expressing certain characteristics. Males pass these genes on to their sons and daughters, while females can only pass them on to their sons. Here sex-linked inheritance of the traits is taken into consideration.

1.5 Genes and Alleles

Genes carry information about the appearance and other physiological characteristics of an organism. They are located at specific sections of the DNA called loci. These segments consist of a large number of subunits called nucleotides. In principle, these nucleotides have the same structure. They consist of a sugar molecule (pentose), a phosphoric acid residue, and an organic base.

The bases are most decisive for the genetic code. There are four different types of bases: adenine (A), thymine (T), guanine (G), and cytosine (C). The sequence of these bases within a gene locus (singular of loci) is responsible for expressing a certain characteristic. If there are changes in this sequence, like due to reading errors during the formation of the germ cells, radioactive radiation, or the effects of poison, this trait's characteristics can change. These changes are known as mutations. Most of these mutations negatively affect the individual, especially when they are related to vital physiological processes.

If a gene is altered due to such mutations, it will now be referred to as an allele (an altered version of a gene). If an individual carries the same gene or allele twice at a certain gene locus, it is called homozygous. If an individual carries two different alleles at a gene locus, it is called heterozygous for that particular trait.

Out of more than one allele, which of the allele will affect the visual appearance of a heterozygous animal depends on the dominance relationships between those alleles. If one allele is dominant over another, it completely or almost completely suppresses the other allele (Fig. 7). The suppressed allele is, therefore, recessive. An allele combination in which both alleles are equally strong is called incomplete dominant. The offspring then will be a mixture of both alleles (Fig. 8).

Dominant inheritance:

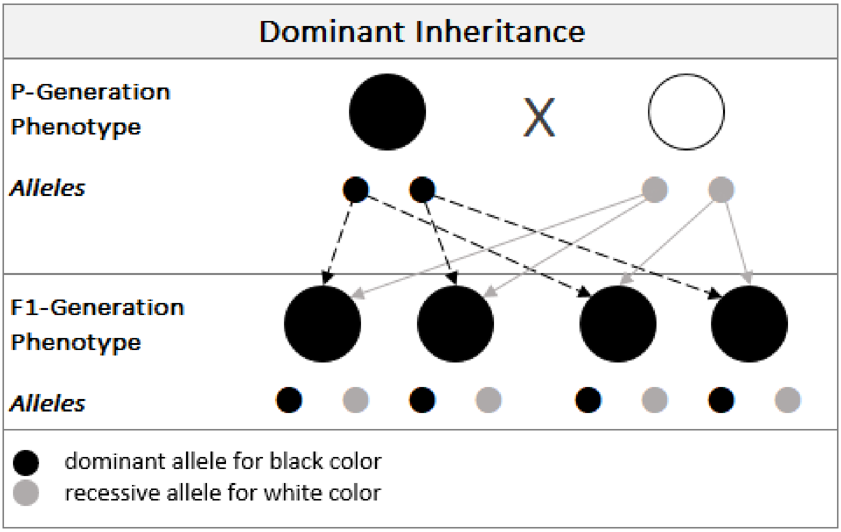


Fig. 7: Dominant inheritance

Incomplete dominant inheritance:

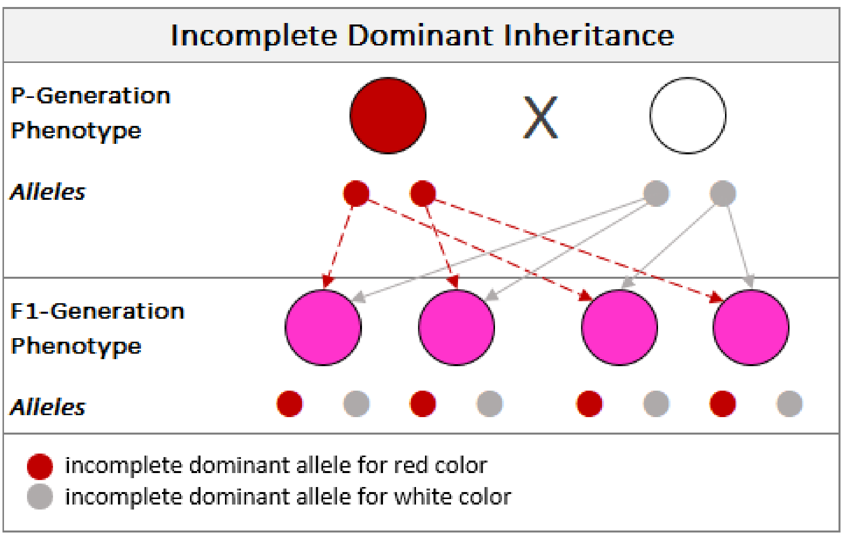


Fig. 8: Incomplete dominant inheritance

To document which genes are carried by an organism, we use letters as proxies for the different genes and alleles. Dominant ones are represented by capital letters (**A, B, C, D,…**) and recessive ones by lowercase letters (**a, b, c, d,…**).

The dominant genes are always listed first. An animal that carries one dominant gene and one recessive (heterozygous) will be listed as **Aa** and not **aA**.

For a particular trait, several different alleles at different loci (plural of locus) can be responsible. Their interaction follows precise rules and orders. With the knowledge learned in the previous chapters, it is possible to predict the outcome of certain allele combinations.

In chapter 1.2, we learned that diploid parent cells would be split up through meiosis into haploid cells. To predict the outcome of a certain cross over, we have to simulate this process. An easy tool for this is the Punnet square. With this matrix, we can calculate the outcomes of all known allelic recombinations.

Example of how to use a Punnet square:

Let's assume that we want to cross a male carrying dominant alleles **AABB** with a female carrying the recessive alleles **aabb**.

Through meiosis, the male and female chromosomes will be split up to all the possible combinations (see Fig. 9). It means that in this case, there are four possible recombinations for each parent.

A simple rule to remember the number of possibilities:

The number of possible combinations is always equal to the number of genes involved.

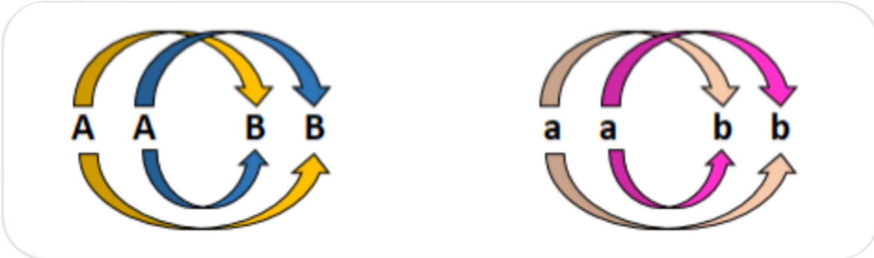


Fig. 9: Possible gene combinations

For male, we have now the following possible allelic genotypes in gametes: **AB, AB, AB, AB,** and for the female we have: **ab, ab, ab, ab.**

As you might notice, all-male combinations are the same and all-female combinations as well (the same genotype).

Therefore, we can break this down to just **AB** x **ab**.

In the next step, we are now entering these possible germ cell combinations in the horizontal and vertical cells (Fig. 10), the male combinations in the vertical and the female in the horizontal.

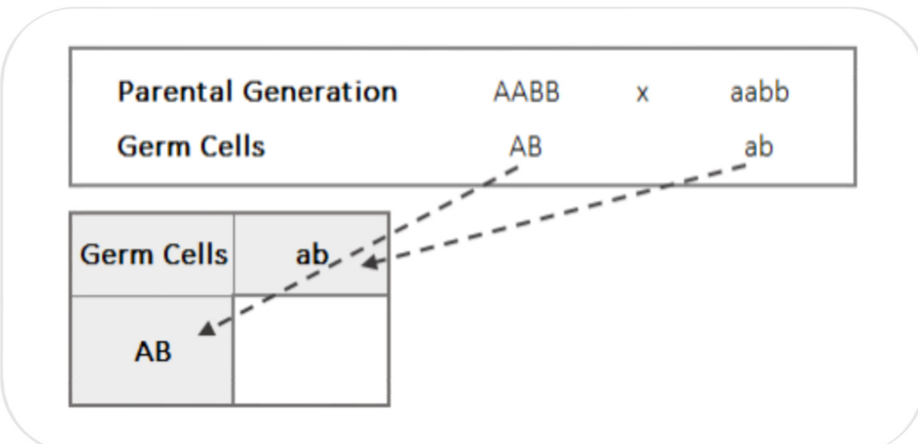


Fig. 10: Punnet square

After the formation of these gametes, the reassembly takes place. In nature, this happens through fertilization, here, we are simulating it on paper (Fig. 11). We then recombine gametes obtained in the step before, just by adding up the allelic genotypes present in the horizontal and vertical fields. The result will then be put in the green highlighted cell. These should happen, of course, in the correct order (dominant genes before recessive ones).

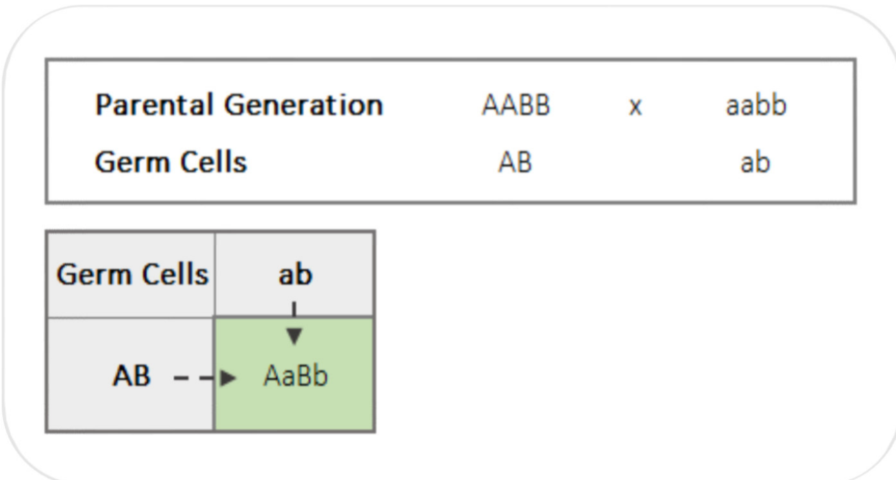


Fig. 11: Punnet square - reassembling

As we can see, the outcome of this specific crossing results in just one genotype and therefore, all the offspring will have the same attributes and traits.

This was an easy example to start with, but the higher the heterozygosity, the more complex the prediction will be. In the next example, I will show the crossing of an **AaBb** male and an **AaBb** female.

As the number of unique combinations is now increased to four, we have to add a few more rows and columns to our matrix. To be exact, we now need four rows and columns.

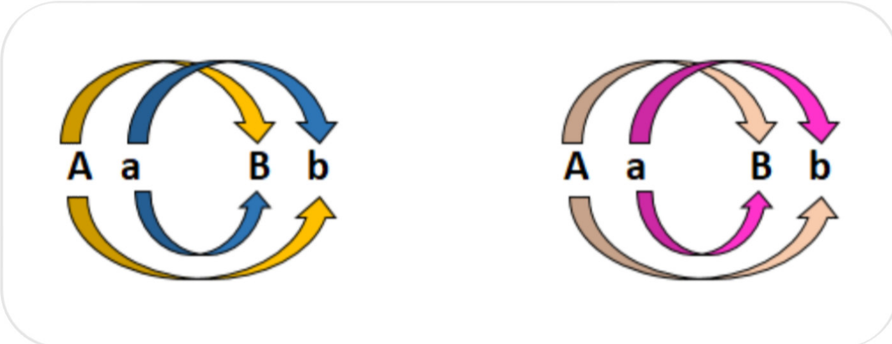


Fig. 12: Possible gene combinations

The possible combinations that result from these two specimens are the following:

Male: **AB, Ab, aB, ab**
Female: **AB, Ab, aB, ab**

In this case, we are not allowed to remove any of these combinations, as all of them are different.

As previously done, we will enter the combinations in the horizontal and vertical cells, the male combinations in the vertical and the female in the horizontal cells. After that, we will be recombining the genes again (Fig. 13).

This time our results look quite different.

For better visualization, genotypes that will show the same traits are colored with the same colors.

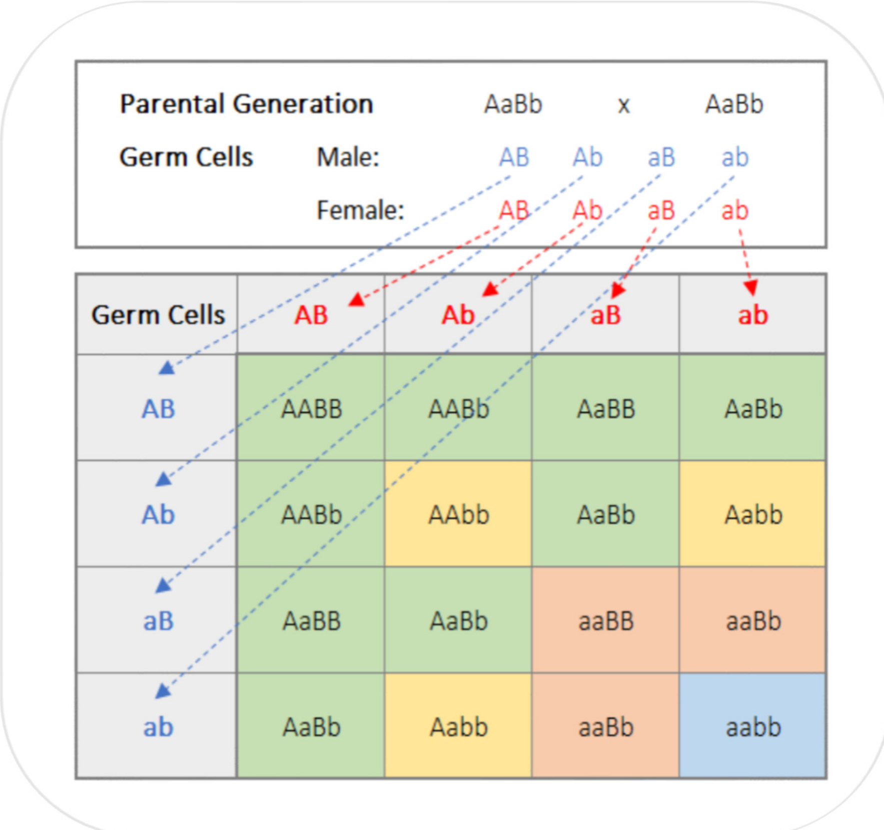


Fig. 13: Punnet square - Example two

In this case, we will receive four different results (highlighted in different colors) with different probabilities. This is due to the interaction of the dominant and recessive genes. Dominant genes will suppress the effects of the recessive genes and are, therefore, more likely to be expressed. This is very important to keep in mind, as you can have hidden (recessive) genes in your flock for a long time without even recognizing them, and suddenly, they will pop up again.

2 BASE COLORS

In Turkeys, the alleles of the MC1R locus are referred to as bronze locus. This locus can accommodate three different alleles. These genes define the basic set of rules of which colors and patterns a turkey can express.

Besides the wild type allele, there also two known mutations of this gene. The wild type gene is referred to as **b**+, better known as Bronze, where the plus (+) indicates that this is the original (wild) form of the gene. This gene's first mutation is the Black allele (**B**) and the second one, the Black-Winged Bronze (**b'**). They follow a certain dominance order: **B** (black) > **b**+ (bronze) > **b'** (black-winged bronze) (Asmundson, 1945).

Both of these mutations cause differences in the plumage's appearance by changing how pigments are produced and stored. Brown, gray and black coloration is caused by the deposition of eumelanin pigments, whereas reddish-brown coloration is caused by pheomelanin (Alexandre Roulin∗, 2013). Due to these mutations of the MC1R locus, the changes in appearance are quite huge.

B and **b'** are both types of melanism, a condition involving dark pigmentation due to a high concentration of melanin. Whereas Black (**B**) is a dominant allele and able to comprise the whole body of the bird, Black-Winged Bronze (**b'**) is a recessive allele with restriction to just the wing feathers (Majerus, 2003).

So if I'm talking about the base color of a turkey, as the book progresses, I always refer to these three alleles of the bronze locus.

2.1 Bronze

The bronze gene is represented by the letter **b+**. As mentioned in chapter 1.5, lower case letters indicate recessive genes.

This gene is responsible for the visual appearance (phenotype) of wild Bronze turkeys, as well as domestic ones.

Bronze turkeys do not carry any other modifying color genes, so if we wrote down the full genotype of a Bronze, it would look as follows:

bb CC dd EE NN RR SlSl SpSp PnPn

As none of the other genes has any extra effects on the phenotype, we can shorten the genotype down to just **bb** and still maintain a clear understanding.

The bronze coloration itself can vary significantly. From a very shiny bronze iridescent coloration, with a high amount of pheomelanin all over the body and tail, to a very dull and pale coloration. Nevertheless, all of them will be referred to as **bb**.

Male (bb):

Fig. 14: Bronze Male by Pasi Hellstén

Female (bb):

Fig. 15: Bronze Female by Pasi Hellstén

Four weeks old (bb):

Fig. 16: Four Weeks Old Bronze

2.2 BLACK

As already mentioned, the first mutation of the bronze gene is the black allele. The black allele is dominant and therefore represented by capital **B**. It is a form of melanism (black coloring, from gr.: melas). This means that a turkey that carries at least one copy of these alleles, like **BB**, **Bb**, **Bb'**, will have the visual appearance of a Black turkey, even if other genes are present.

Even though this gene is dominant over the other two, heterozygosity for other genes can be determined in these birds.

There are small hints, like some single Bronze or Black-Winged Bronze feathers. Especially the primary wings are a good indicator of heterozygosity. Turkeys with a split base color (heterozygous base color) will show a slight barring in their primary wing feathers.

Fig. 17: Bird's Wing

1. Primaries	*2.Primary Coverts*	*3. Alula*
4. Secondaries	*5. Greater Secondary*	*6. Median Coverts*
7. Lesser Coverts	*8. Terials*	*9. Scapulars*

Male (BB):

Fig. 18: Black Male by Pasi Hellstén

Female (BB):

Fig. 19: Black Female

Day old (BB):

Fig. 20: Day Old Black

Feather Pattern:

Fig. 21: Detail - Lower back, bronze tipped feather edges

Fig. 22: Wing detail - Bb'

Barring in the primaries is a typical sign of a heterozygous Black turkey. In this case, the turkey carries a single Black-Winged Bronze allele (**Bb'**).

Fig. 23: Tail Detail – Bb'

Also, a good indication of a heterozygous base color locus are feathers of a different color than black. In this case, you can spot the tail feather of a Black-Winged Bronze (**Bb'*)*** in between the otherwise black feathers.

2.3 BLACK-WINGED BRONZE

The second and last base color mutation is the Black-Winged Bronze (*abbrv. BWB*) allele. The presence of this gene is represented by the letter **b'**.

Black-Winged Bronze genes are the least dominant of all three genes of the bronze locus. Nevertheless, there are some indications that allow us to determine whether a bird carries **b'** genes or not. In Black and Bronze turkeys, you might spot some single Black-Winged Bronze feathers. In Bronze turkeys **b’** can reduce the barring in the primaries, while in Black turkey, the opposite effect can be observed. Here it leads to a slight barring in the primary feathers. For a complete change of the phenotype, a turkey has to carry two copies of this gene (**b’b’**).

Male (b’b’):

Fig. 24: Black-Winged Bronze Male

Day old poult (b’b’):

Fig. 25: Day old Black-Winged Bronze

Twelve weeks old (b’b’)

Fig. 26: Twelve Weeks Old Black-Winged Bronze.

Fig. 27: Wing Detail (bb')

When a Bronze turkey carries a single Black-Winged Bronze allele, the absence of barring in the primaries can be observed. Often this is not that easy to spot, as in some indiviuals, the barrings are just slightly merged.

Fig. 28: Body Detail (Bb')

In Black turkeys, especially when they carry a gray (**cg**) gene, you can pretty easily determine whether they carry a BWB gene or not by just checking for the presence of some Sweetgrass or Palm like feathers.

Fig. 29: Black-Winged Bronze Male by Melchior de Hondecoeter (1694)

Fig. 30: Black-Winged Bronze Male by Jan van Kessel the Elder (1675)

3 Modifiers

Now that we know the base colors of turkeys, we can move forward to the modifiers.

Modifiers can change the way and the amount of how pigments are produced and stored in the feathers. Some color genes might also affect other areas of the bird, like eye or shank color.

These modifiers are responsible for making a turkey appear red, blue, brown, white, or to have a specific color pattern.

The effects of these modifiers depend very much on the base color mutation of the specific turkey.

While in some base colors, genes can cause extreme visual changes, in others they might have barely any effect.

Due to a large number of modifying genes, more than 30,000 different color combinations can be produced. Only a fraction has been bred until this day, and even less are well documented.

In this book, I will introduce you to the following loci and their possible genes and mutations:

b	C	d	E	N	R	Sl	Sp	Pn

To make it more clear what genes are currently affecting and altering the color, I will just write these genes down.

For example, instead of writing **BB CC dd EE NN RR SlSl SpSp PnPn,** I will just write down **BB**, as all the other genes remain unchanged from the wild type genotype.

Therefore, the more genes we will change, the longer the genotype will be.

At the end of this book, you'll be able to understand what color and sex a turkey with the genotype **Bb' cgcg dd e- n- RR SlSl SpSp PnPn** will have.

3.1 Color Expression

This locus is responsible for the amount of color that a turkey can express. Besides the wild type, there are two known mutations that can be present at this locus.

Each of them has a very different visual impact on the three base colors.

The names of the alleles on this locus are:

Full color expression (wild type) (C)
White (c)
Gray (cg)

Dominance chain of the genes: C > cg > c

Fig. 31: Full color expression (top left) - Gray (top right) - White (bottom)

3.1.1 Full color expression

The first gene at this locus is the dominant, full color expression gene, also known as wild type. This gene is the original form that can be found in wild turkeys. It is represented by the capital letter (**C**).

Many different varieties are carrying this gene. For example, Bronze, Black, Black-Winged Bronze, Bourbon Reds, Slates, …

As you might recognize, all of these varieties look completely different. Nevertheless, they all share a part of their color genetics.

Male (BB CC):

Fig. 32: Black male - by Pasi Hellstén

Male (bb CC):

Fig. 33: Bronze male - by Pasi Hellstén

Male (b'b' CC):

Fig. 34: Black-Winged Bronze Male

3.1.2 White

One mutation of the wild type gene is the white gene. This gene is recessive, and its presence is represented by the lower case letter **c**. If there are two copies of the white gene present, it prevents the deposition of color pigment in the feathers and, in some cases, also the eyes. Therefore, it does not matter what other color genes a turkey would carry; the result will always be a completely white bird.

A Turkey with the genotype **BB cc** is white, even though its base color is black. Nevertheless, there are some ways to determine the base color of a white turkey. The first method involves the down color of the poult (chapter 9). Based on the color, you can rule out certain possibilities. Another way is by checking your specimen's eye color (chapter 3.1.2.1), and the last method is by making a test mating (chapter 4).

Male (bb cc):

Fig. 35: White Male by Heather Barlow

3.1.2.1 Eye Color:

Depending on the turkey’s base color, the white gene can have different effects on the pigmentation of the turkey’s eye. While black-based turkeys tend to have blue eyes, Bronze and Black-Winged Bronze turkeys usually have brown eyes.

BB cc

b’b‘ cc

b+b+ cc

3.1.2.2 Color leakage:

Fig. 36: A single black feather in an otherwise white turkey

Even though recessive white inhibits pigment deposition, some color leakage can sometimes occur, like some single full-colored feathers.

3.1.3 Gray

The next mutation at this locus is the gray allele (**cg**). It reduces the amount of pheomelanin (red-brown pigments) and diffuses the black color of the flight feathers (Sponenberg). The effect of **cg** varies a lot. Depending on the base color mutation, this can lead to very different results.

The biggest impact can be found in Black-Winged Bronze turkeys, where the red and brown pigments can be reduced to just a tiny little residue. A typical example of this effect is the Sweetgrass turkey, also known as Yellow Shouldered Ronquiéres in Europe.

Male (b′b′ cgcg):

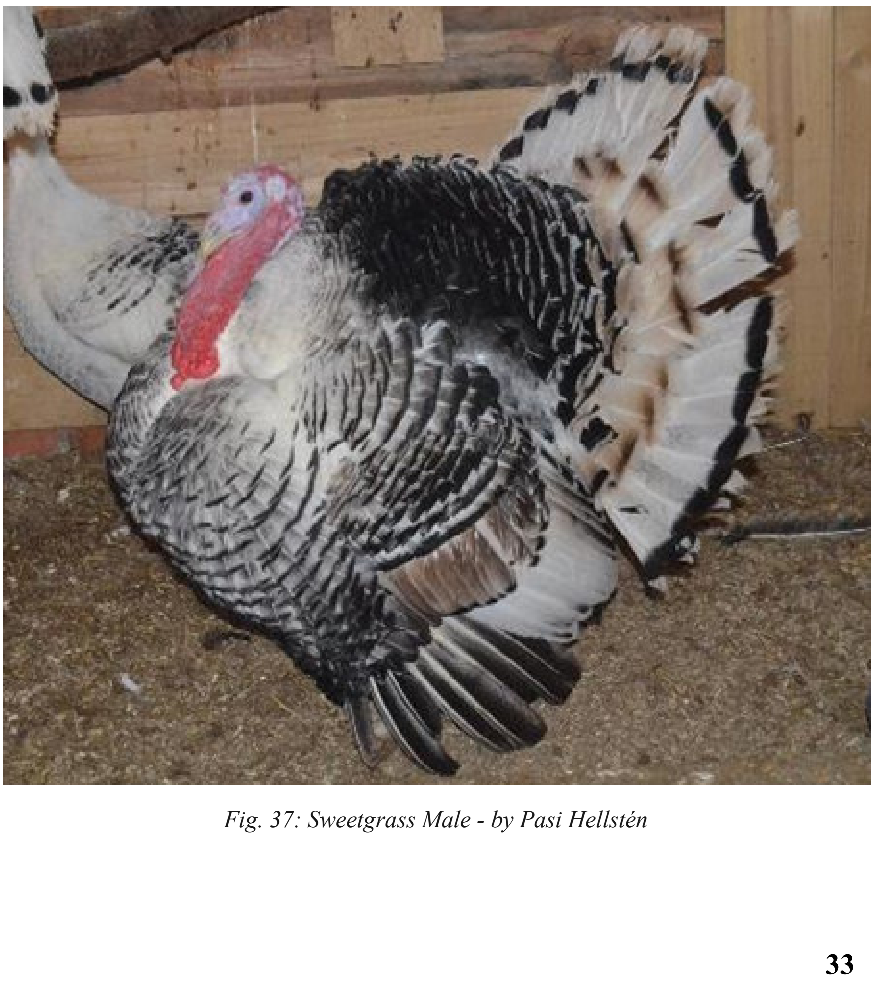


Fig. 37: Sweetgrass Male - by Pasi Hellstén

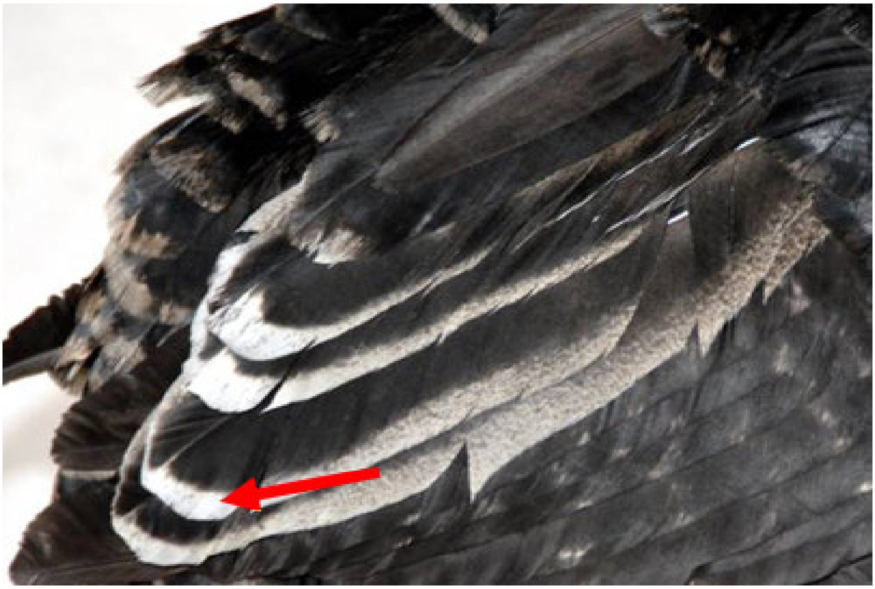


Fig. 38: Wing Detail - Bb' cgcg
The gray gene causes the typical white edges on the secondaries.

Fig. 39: Effect of homozygous gray (cg) in dominant Slates.
The uniform slate color will be replaced by a grizzle pattern.

Fig. 40: Painting of Joachim Beuckelaars (1566) with a Ronquiéres turkey (European equivalent of Sweetgrass turkeys).

Fig. 41: Detail of Ronquiéres turkey

3.2 Red

r (red) / **R** (non-red)

The next modifier I want to discuss is the red gene. It is responsible for the excessive production of red pigments (pheomelanin). It also has diluting properties to all black pigments (eumelanin).

The red gene is represented by the lower case letter **r**. As you already know, this means it is recessive compared to the non-red version of this gene (**R**).

However, this allele is not completely recessive, it's incomplete recessive. Therefore, a bronze turkey with a single copy of red shows a slightly reddish coloration. If ***r*** would be completely recessive, then this wouldn't be the case. So even a single dose of this gene is able to affect the appearance of the turkey, although not in the same way as two copies would do.

Male (bb rr):

Fig. 42: Bourbon Red Male by Michael Kümpel

Female (bb Rr):

Fig. 43: Red Bronze Female

Black leaking in a Jersey Buff (BB rr):

Fig. 44: Black leakage in a Jersey Buff

Fig. 45: Feather Detail – Red Bronze (bb Rr)

Fig. 46: Swirling Pattern in the Alula and Primary Coverts

Even in heterozygous individuals, an increase of pheomelanin pigmentation can be observed. The black pigmentation on the other hand is reduced. This leads to a swirling pattern in otherwise solid black areas.

3.3 NARRAGANSETT

n (Narragansett) / **N** (non-Narragansett)

Narragansett genes are represented by the letter **n**, while non-Narragansett genes are represented by **N**.

Narragansett genes have the ability to reduce the amount of pheomelanin in the plumage of a bird. In general, this leads to a much lighter phenotype than compared to a standard Bronze turkey. Nevertheless, this effect can vary a lot, depending on the turkey's base color and the modifying genes.

Very interesting about this gene is that it is sex-linked. That means it can only be located on the Z chromosomes (sex-chromosomes). Therefore male Narragansetts have to carry two copies (homozygous), while females need to carry just one copy (hemizygous) of this allele.

Due to that, the genotype of a Narragansett male is **bb nn**, and that of a female is **bb n-**.

As you may have noticed, the missing allele of the hen is represented by a minus (**-**). This indicates that there is no available locus for a second copy of this allele. You can read more about sex chromosomes in chapter 1.4. (W. R. B. ROBERTSON, 1943)

The unique behavior of this sex-linked inheritance gives us some exciting possibilities.

We can use this allele to create a sex-linked mating, resulting in males of one color and females of another. This way, we can determine the sex of the poults easily just by the color of their own. Homozygous (males) and hemizygous (females) do show a lighter color pattern than their non-Narragansett counterparts. This effect can be observed in almost all varieties with Narragansett genes, but especially in those with markings on their heads and back.

Male (bb nn):

Fig. 47: Male Narragansett by Jens Hörl

Female (bb n-):

Fig. 48: Female Narragansett by Jens Hörl

Comparison:

Fig. 49: Black-Winged Bronze (left) and Black-Winged Narragansett (right)

In the pictures above, the color genes are identical except for the Narragansett genes. Both of them are Black-Winged Bronze-based. The visual appearance is quite different.

The male on the left is much richer in bronze color, while the bird on the right lacks bronze pigmentation in most areas.

The effects of the Narragansett genes can be best observed in the primary and secondary coverts, as well as in the tail feathers, where the effect is the biggest. This is of utmost importance to know to correctly identify the presence of this gene.

3.4 SLATE (DOMINANT)

D (slate) / **d** (non-slate)

This gene reduces the amount of black pigments, which causes the bird to end up greyish blue. The effects on red or brown color are negligible. Only a slight dilution can be observed.

A single copy of the slate gene (**Dd**) can be determined by some dark speckles bleeding through the otherwise solid blue feathers. Only two copies of this gene can change the whole body into a uniform blue coloration.

The intensity of slate color decreases with the number of copies of this gene. So the color of a heterozygous bird will always be much darker than those with two copies (homozygous).

Homozygosity of this gene is also often associated with impairments of the visual and auditory senses. For some reason, females appear to be more likely to be affected by blindness and deafness.

Fig. 50: Wing Detail (Dd)
Black sprinkles bleeding through the slate color.

Fig. 51: Chest Detail (Dd)
Some feathers are completely unaffected by the slate gene.

Fig. 52: Tail Detail (DD)
Slight changes in brown and red color

3.5 Slate (recessive)

sl (recessive slate) / **Sl** (non-recessive slate)

This gene also causes a grayish coloration. Its effect on the whole body is much more even compared to the effects of the dominant slate genes. Even areas with red color will be changed to an almost solid gray, but because it is recessive, two copies are needed (**slsl**).

Male (bb slsl):

Fig. 53: Recessive Slate by Lydie Čajková Pecháčková

3.6 Brown

e (brown) / **E** (non-brown)

Brown is a sex-linked recessive allele. It will alter all the bronze and black color to brown. Males need a double dose of this gene (homozygous) to express the brown color, while females just need one copy (**e-**) (hemizygous).

The brown color is heavily affected by the sun, causing a fading of the dark brown color to a very light and uneven brown.

Male (BB ee):

Fig. 54: Auburn Male by Kevin Porter (Porter's Rare Heritage Turkeys)

3.7 PENCILLING

pn (pencilling) / **Pn** (non-pencilling)

Pencilling is a recessive gene. It alters the usual feather pattern to a black pencil-like, vertical pattern. This gene needs the presence of the Black-Winged Bronze allele to be able to express itself. It can't be observed in Bronze or Black turkeys, even if they are homozygous for it.

Male (b'b' cgcg nn pnpn)

Fig. 55: Pencilled Palm Male

Fig. 56: Pencilled Palm - Lower Back and Wing Feathers

Fig. 57: Pencilled Palm - Tail Feather

Typical feather pattern of a Pencilled Palm. Vertical lines are added in areas that would otherwise be white. The presence of gray (**cg**) makes the pattern much more visible as the reddish-brown colors will be diluted.

Fig. 58: Painting by Carstian Luyckx (1653)

Fig. 59: Detail - Pencilled Palm Male

3.8 Spotting

sp (spotting) / **Sp** (non-spotting)

The spotting gene (**sp**) suppresses the pigmentation of large areas of bird, just near the quills, and at the edges of the feathers, some color can be found (ASMUNDSON, 1955). This mutation existed in the US and UK till it slowly disappeared. Currently, there are no living individuals known.

Male (bb spsp):

Fig. 60: Spotted Male by David Sanderson

Females (bb spsp):

Fig. 61: Spotted Females by David Sanderson

Day old poults (bb spsp):

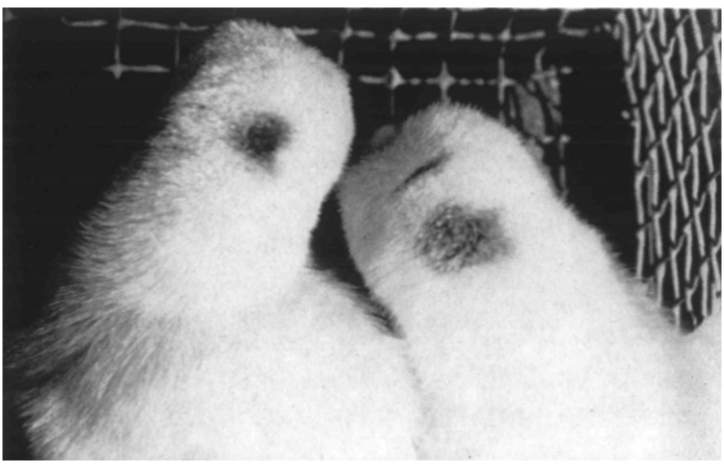


Fig. 62: Day old poults have a white down except for a brown head (ASMUNDSON, 1955).

3.9 IMPERFECT ALBINISM

al (imperfect albinism) / **Al** (no imperfect albinism)

Imperfect albinism eliminates nearly all pigment from the plumage. Poults affected by this mutation are blind. The condition is caused by a sex-linked recessive gene **(al)**, which is lethal in about 75 percent of the cases during the embryonic development of females. Most albinotic poults die within six weeks of hatching, mostly due to their handicap imposed by their blindness (F. B. HUTT, 1942).

Female (bb alal):

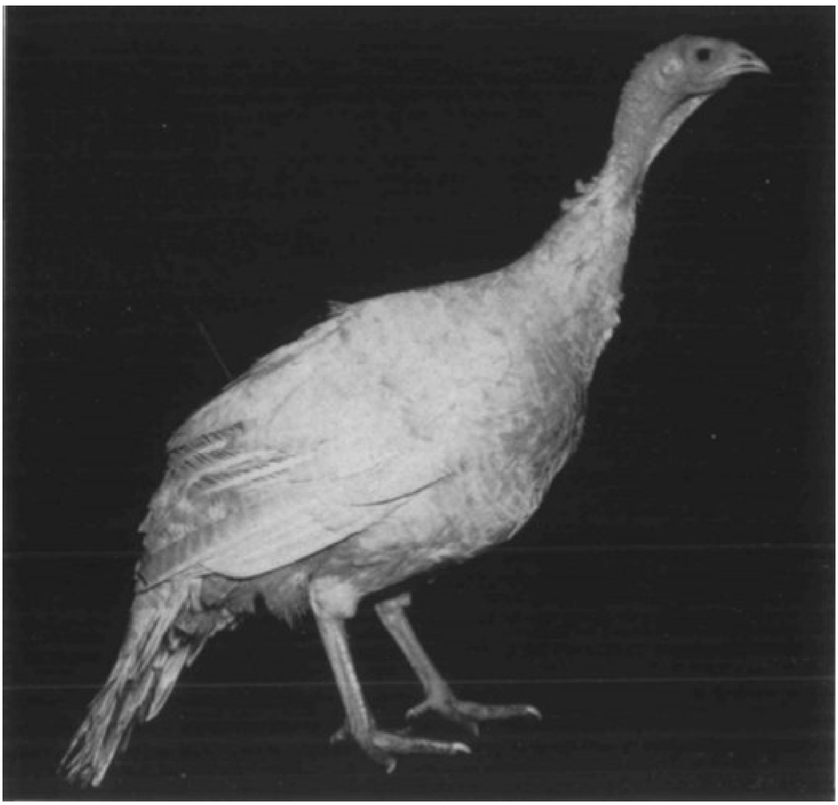


Fig. 63: Albinotic Female by "The Journal of Heredity"

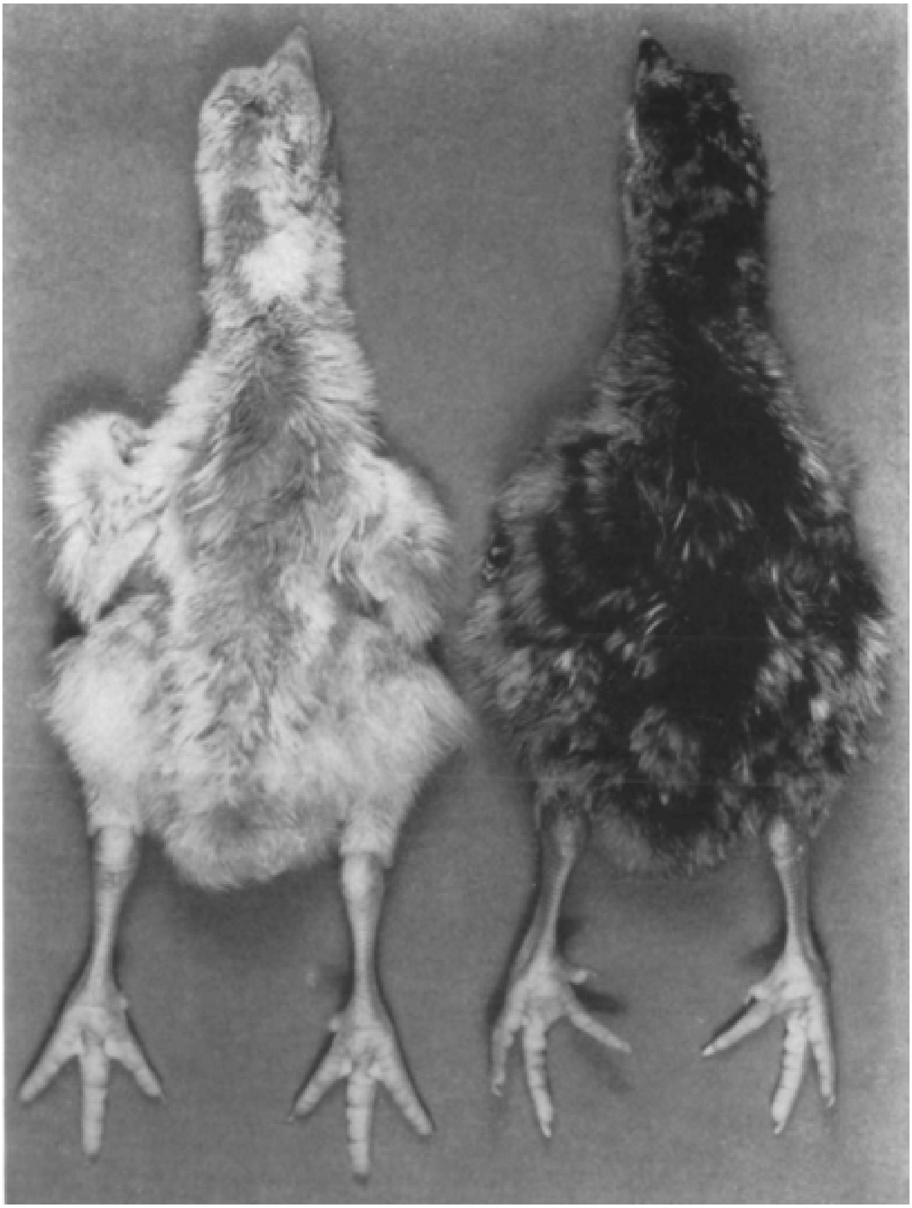


Fig. 64: Albinotic and normal Bronze poults (F. B. HUTT, 1942)

Some traces of pigments can be found in the albino poult.

4 PREDICTION OF COLORS

In this chapter, I will go deeper into the method of predicting the outcomes of certain matings. The tool of choice will be the Punnet square.

With this matrix, we can calculate the probabilities and outcomes.

The more used to it you are, the easier it will be for you to predict any outcome, even without the support of drawing down the matrix, or using a digital version of it.

In specific cases, the matrix is also able to tell you the sex of the offspring. This is always the case when there are sex chromosomes, like **n** or **e** involved.

You can find the digital version under the following link:

https://www.porterturkeys.com/turkeycolorcalculator.htm

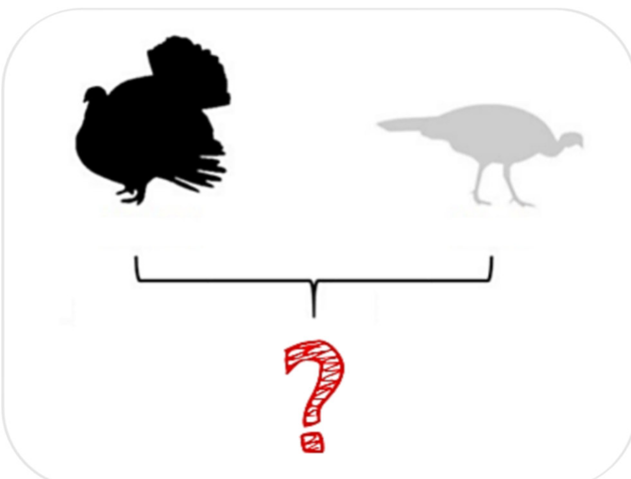


Fig. 65: Color prediction

4.1 Example 1: Black x White

In our first example, we want to predict the outcome of the mating of a Black male and a White female. The genotype of the Black male is **BB**(**CC**), and those of the White female is **BBcc**.

As there is just one possible germ cell combination for each parent, we can break it down to **BC** x **Bc**.

First, we are entering the gene combinations provided by both parents, and then we are combining them in the green highlighted cell. For a deeper explanation of how the matrix works, have a look at chapter 1.5.

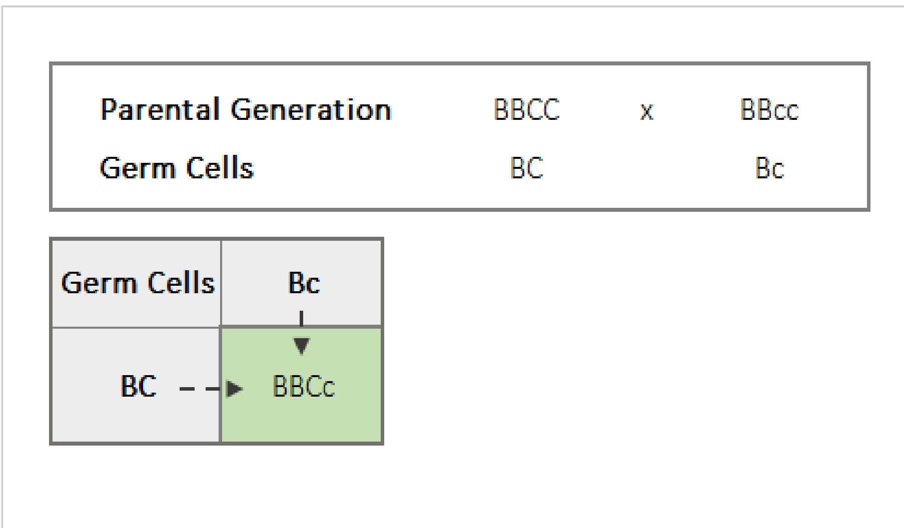


Fig. 66: Prediction of Genotype

The result of this cross is turkeys with the genotype **BBCc**, or in other words, Black turkeys with one copy of the white gene.

4.2 EXAMPLE 2: RED BRONZE X RED BRONZE

Ever wondered what might be the result of breeding Red Bronze? Well, in a few moments, you will know.

The genotype of a Red Bronze is **bbRr**. As you already know, this means that this turkey is heterozygous for red.

Again we will use the combination-matrix to solve this riddle, but this time we need a minimum of two rows and columns to enter all the possible gene combinations. You might wonder why we need just two rows and columns, although we have four possible combinations for each parent.

Let's have a look at the possible combinations. For the male, we have **bR, br, bR, br** and the same for the female. Due to the fact that both **bR** and both **br** would produce the same results, we can remove one of each from the equation without altering the result.

Germ Cells	bR	br
bR	bbRR	bbRr
br	bbRr	bbrr

Fig. 67: Prediction of the genotype

As you can see, this mating results in three different genotypes. 1/4 will be **bbRR** (Bronze), 1/4 will be **bbrr** (Bourbon Reds) and 2/4 will be **bbRr** (Red Bronze).

4.3 Example 3: Slate x Sweetgrass

This one will be more complex, as we are adding another set of genes to the equation. The genotype of a Slate is **BBCCDd,** and that of a Sweetgrass is **b‘b‘cgcgdd**.

In the first run, I will show you how the complete calculation would look like, and after that, I will show you how to reduce the calculation down to just what is necessary.

First run:

We are entering all the possible gene combinations into the matrix (six for both parents) and are then recombining them.

Parental Generation	BBCCDd		x		b'b'cgcgdd	
Germ Cells	BCD	BCd	BCD	BCd	BCD	BCd
	b'cgd	b'cgd	b'cgd	b'cgd	b'cgd	b'cgd

Germ Cells	b'cgd	b'cgd	b'cgd	b'cgd	b'cgd	b'cgd
BCD	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd
BCd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd
BCD	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd
BCd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd
BCD	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd	Bb'CcgDd
BCd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd	Bb'Ccgdd

Fig. 68: Complete prediction of genotypes

As you can see, even with these six combinations per parent, the cross results in just two different genotypes **Bb'CcgDd** (Tri-Color Mottled Slate) and **Bb'Ccgdd** (Tri-Color Mottled Black). Both with a ratio of 50%.

Second run:

Now we are removing all the unnecessary combinations from our matrix. The male can provide just two possible combinations, either **BCD** or **BDd**, and both are equally distributed. The female does have even less possibilities. The only combination she can provide is **b'cgd**. Therefore, the whole prediction can be done with just one column and two rows and would still give us the same results:

50% **Bb'CcgDd** (Tri-Color Mottled Slate) and 50% **Bb'Ccgdd** (Tri-Color Mottled Black).

Parental Generation	BBCCDd		x		b'b'cgcgdd	
Germ Cells	BCD	BCd	BCD	BCd	BCD	BCd
	b'cgd	b'cgd	b'cgd	b'cgd	b'cgd	b'cgd

Germ Cells	**b'cgd**	***b'cgd***	***b'cgd***	***b'cgd***	***b'cgd***	***b'cgd***
BCD	Bb'CcgDd	Bb'CcgDd	*Bb'CcgDd*	*Bb'CcgDd*	*Bb'CcgDd*	*Bb'CcgDd*
BCd	Bb'Ccgdd	Bb'Ccgdd	*Bb'Ccgdd*	*Bb'Ccgdd*	*Bb'Ccgdd*	*Bb'Ccgdd*
BCD	*Bb'CcgDd*	*Bb'CcgDd*	*Bb'CcgDd*	*Bb'CcgDd*	*Bb'CcgDd*	*Bb'CcgDd*
BCd	*Bb'Ccgdd*	*Bb'Ccgdd*	*Bb'Ccgdd*	*Bb'Ccgdd*	*Bb'Ccgdd*	*Bb'Ccgdd*
BCD	*Bb'CcgDd*	*Bb'CcgDd*	*Bb'CcgDd*	*Bb'CcgDd*	*Bb'CcgDd*	*Bb'CcgDd*
BCd	*Bb'Ccgdd*	*Bb'Ccgdd*	*Bb'Ccgdd*	*Bb'Ccgdd*	*Bb'Ccgdd*	*Bb'Ccgdd*

Fig. 69: Simplified genotype prediction

4.4 Example 4: Royal Palm x Red Bronze

This last example will be the toughest one because now we are also taking sex-linked genes into account.
The Royal Palm male carries the genes **b'b'cgcgnnRR,** and the Red Bronze female carries **bbCCN-Rr**.

Therefore, there is only one possible gene combination provided by the male **(b'cgnR)** and four by the female (**bCNR**, **bCNr, bC-R, bC-r**).

Parental Generation	b'b'cgcgnnRR	x	bbCCN-Rr
Germ Cells	b'cgnR		
	bCNR bCNr bC-R bC-r		

Germ Cells	bCNR	bCNr	bC-R	bC-r
b'cgnR	bb'CcgNnRR	bb'CcgNnRr	bb'Ccgn-RR	bb'Ccgn-Rr

Fig. 70: Sex-link genotype prediction

The result of this example is very interesting, because from the different results you can also tell the sex of the offspring. As learned in chapter 1.4, female turkeys do carry allosomes (sex chromosomes). That means, as soon as we see a genotype with one missing gene, we know that this must be a female. The absence of a gene is indicated by a "**-**".

So, the outcome of this mating is the following:
25% **bb'CcgNnRR** (Bronze males)
25% **bb'CcgNnRr** (Red Bronze males)
25% **bb'Ccgn-RR** (Narragansett females)
25% **bb'Ccgn-Rr** (Golden Narragansett females)

5 INHERITANCE SCHEMES

On the following pages, I will introduce you to a few different types of inheritance schemes.

All of them will give you an overview of the specific mating outcome, but all in a slightly different way.

The first scheme gives you a quick overview of the color outcome but doesn't grant you a deeper look into genetics.

Black x White:

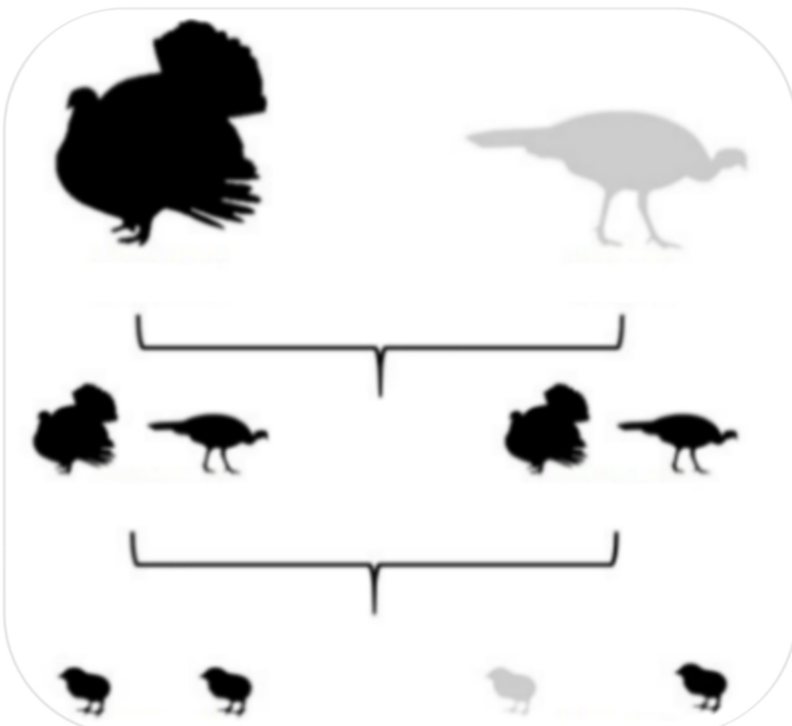


Fig. 71: Inheritance Scheme - Black x White

The second type of scheme is less graphical but gives you also an idea about what you might expect from certain breeding.

The phenotype of the bird is represented by the color of the square. Brown means Bronze, and light pink means Narragansett. This scheme also indicates the hidden gene (recessive genes). They are indicated by small squares in the lower right corner. These hidden genes might not change the turkey's phenotype, but they can be passed on to the next generations and cause you some interesting experiences.

Bronze x Narragansett:

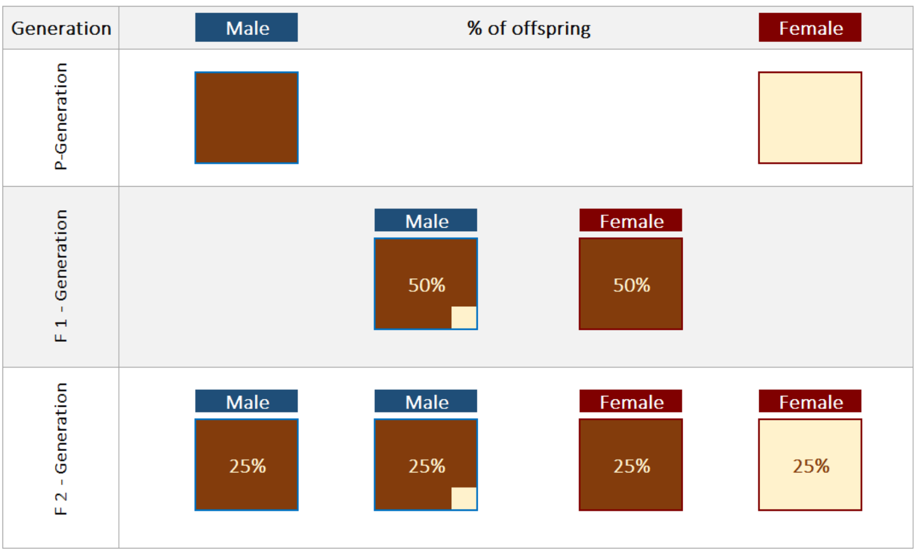


Fig. 72: Inheritance scheme - Bronze x Narragansett

As you can see, the filial generation 1 (F1) will look like standard Bronze, but all the males will carry a hidden Narragansett gene (**Nn**).

In F2, you will have a 25% chance to get pure Narragansett females, while the rest of the offspring will look like ordinary Bronze turkeys.

A completely different outcome will be produced by crossing a Narragansett male and a Bronze female.

As described in chapter 1.4, a sex-linked gene causes this effect. In this particular case, it's the Narragansett gene that's responsible for this strange result.

Narragansett x Bronze:

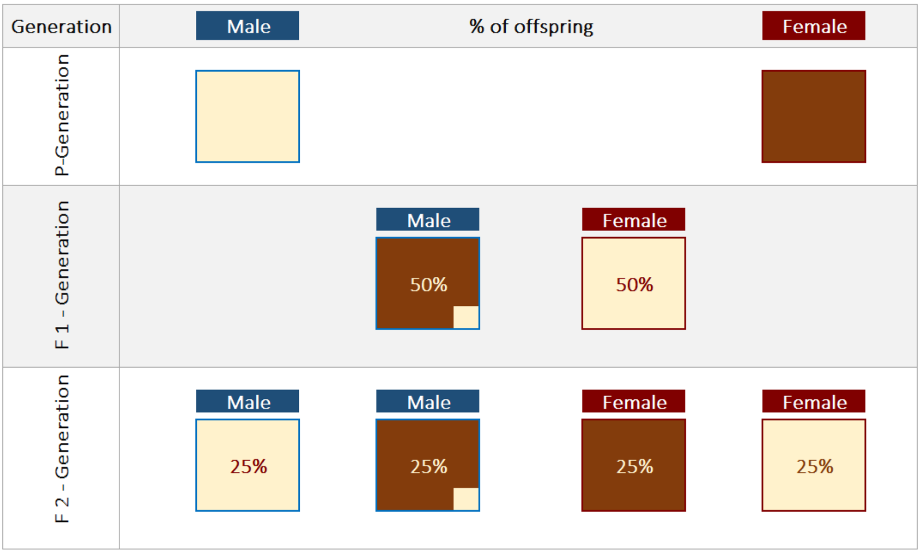


Fig. 73: Inheritance scheme - Narragansett x Bronze

This combination produces 50% Bronze males and 50% Narragansett females in the first generation. This is kind of odd, as it is the exact opposite of what we originally mixed. Such results are always a good indication of the involvement of sex-linked genes.

In the F2, you'll receive 50% Bronze and 50% Narragansetts, evenly distributed on both sexes. It is also very interesting to note; that all of the offspring, except for the Bronze males, will be true-breeding. Therefore, it is advisable to remove such impure birds from your flock, to keep unwanted side effects low.

Impure Birds:

It is always quite challenging to work with impure (none true-breeding) birds.

Even if both parents might appear like regular (pure) birds, they can carry hidden genes. Those genes can be hidden for many generations till they finally pop up. Therefore it can be a really hard job to get rid of these unwanted genes.

In this example, I will show you what happens if you mate a Bronze male (carrying a hidden Narragansett gene) with a pure Bronze female.

Bronze (impure) x Bronze:

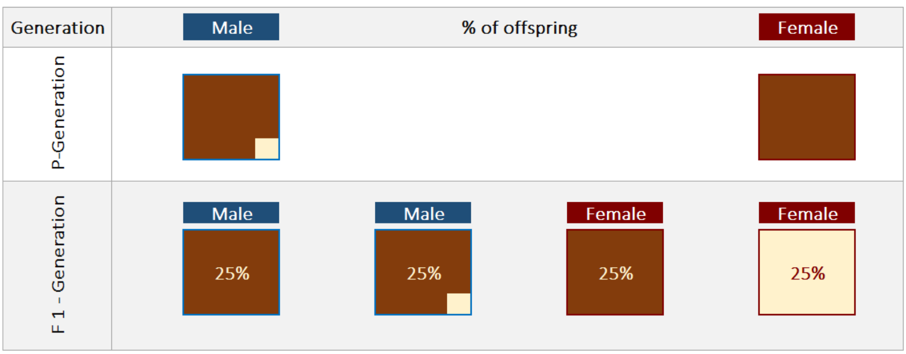


Fig. 74: Inheritance scheme - Impure birds

In your first generation, you will already end up with some Narragansett females in otherwise Bronze colored offspring.

This is always an indication that your sire isn't completely pure. If you aim to produce just pure birds, you should remove such a male from your flock.

You also have to be aware; that 50% of the males that were produced carry also a copy of the hidden Narragansett gene. Therefore, you have to be extremely cautious if you want to work further with these males. Keep an eye on the results that these males will produce; only then can you assure a completely true-breeding flock.

The presence of a hidden Narragansett gene can also be proven by mating the suspected male with a Narragansett female.

Bronze (impure) x Narragansett:

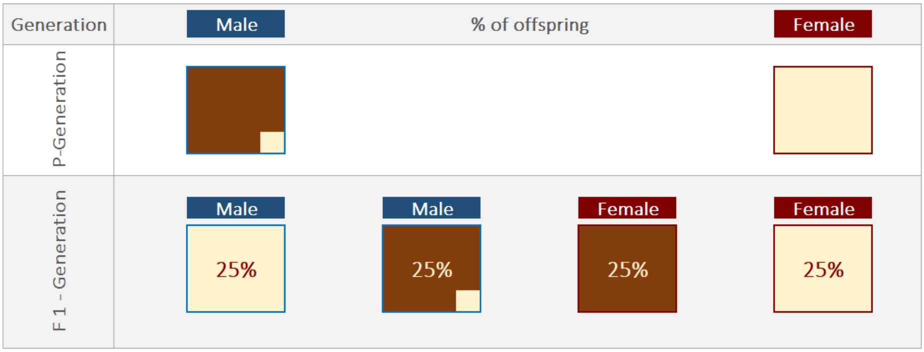


Fig. 75: Test breeding for hidden genes

If any Narragansett results from this mating, you can be sure that your male carries one copy of this gene.

The Narragansett that results from this breeding is pure for this trait. If your aim is to establish a new line of this variety, you can just go ahead with these birds.

This method also works for all other recessive genes. If you have a suspicion and you want to substantiate it, this is the method of choice. Set up a breeding pen with the suspected specimen and a proven true-breeding one, and if they produce any offspring with a true-breeding phenotype, you can be sure both parents carry these genes.

Please consider that such statistical numbers are not always fully reliable.

Even if you should statistically receive 25% or even 50% of a specific phenotype, it can be the case that the odds are against you. Especially if you incubate a small number of eggs, you can't be a hundred percent certain.

6 INBREEDING

Inbreeding is the mating of related individuals that have one or more common ancestors. We distinguish between two forms of inbreeding.

Close inbreeding:

The closest form involves the mating between full brothers and sisters (full siblings) and between parents and their offspring (first-degree relatives).

The second closest form is the mating of grand-parents, half brothers and sisters (half-siblings), uncles/aunts and nephews/nieces.

The more closely related the parents, the greater their offspring's chance of suffering from an inherited disorder. This is due to the fact that those close relatives are far more likely to carry the same defective genes. When these defective genes pair up in the offspring, inherited diseases can occur. Inherited diseases can cause significant suffering and reduce the quality of life.

Line breeding:

Line breeding is a milder form of inbreeding and is usually directed towards the goal of improving certain traits. The degree of relationship is not closer than half-brother half-sister matings or cousin matings, and so on.

To visualize how much of the genome will be provided by each parent, we can use a simple illustration (Fig. 76). This scheme is very important to understand how inbreeding actually works. By selecting the breeding stock, you can influence the inheritance of certain traits. The more traits of a specific individual you want to introduce into your lines, the more you have to steer your matings towards this individual's genetics. The same is true if you want to introduce a new gene or trait into your flock.

You have to make a plan how to achieve this most efficiently, without harming your breeding stock.

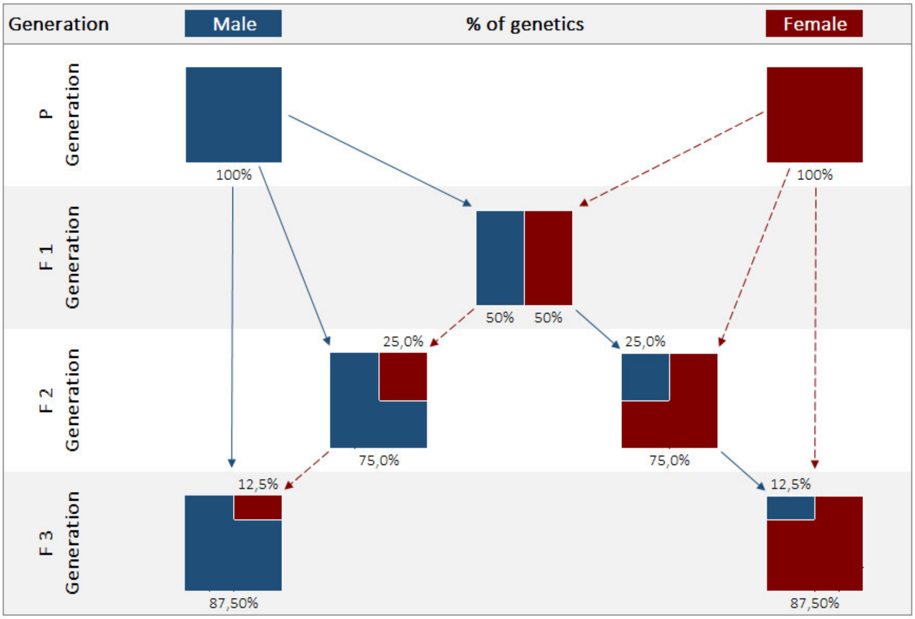


Fig. 76: Inbreeding Scheme

In this illustration, you can see how much of the genetic information is provided by each parent. This is of utmost importance if you want to increase desirable traits or get rid of unwanted ones.

For example, in the F1 generation, both parents are providing 50% of the genetic makeup. Depending on what direction you want to go from here on, you can either increase or reduce this amount in the next generation (F2).

The longer you are selecting for certain traits, the less variation you will have within your offspring. This practice is best known from meat chicken and laying hens, where close inbreeding takes place for more than twenty generations. Due to this drastic approach of inbreeding, the appearance of these birds is fully uniform in size and performance.

In the next illustration, you can see a few more possibilities of altering your breeding stock's genetic composition by selecting a specific mating partner.

With good flock management, you can maintain a certain level of genetic diversity and therefore ensure a robust and resilient flock.

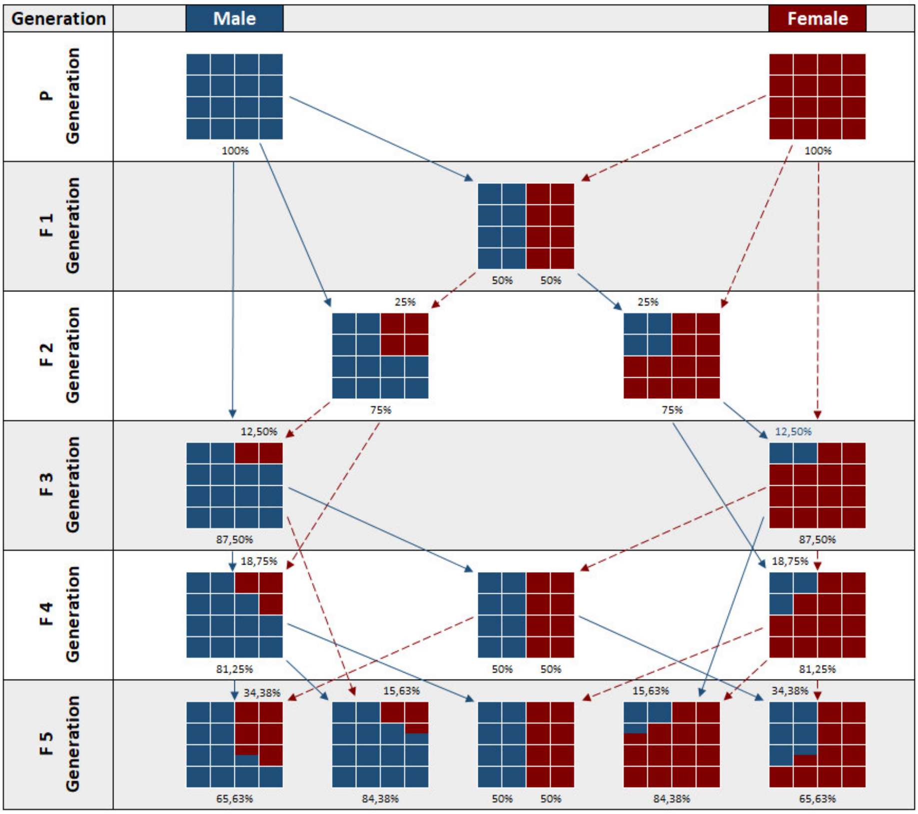


Fig. 77: Flock management

Even after five generations of close inbreeding, you can still produce birds with high genetic diversity, just by following a strict plan and keep tracking the pedigree.

7 Color Combinations

In this chapter, I will introduce you to different varieties, from all three base colors.

As we add and combine more and more different alleles, you can see how they interact with each other. Some of these effects might be barely visible, while others can be immense. Especially the base color mutation plays a huge role in the expression of the different modifying alleles.

Please be aware that this is just a small excerpt of what is actually possible.

There are more than 30,000 possible color gene combinations and, therefore, enough material to write 150 books about.

Fig. 78: Color Combinations

7.1 AUBURN

Male (bb ee):

Fig. 79: Auburn Male by Nick Baldo

Auburn is a bronze-based variety (**b**). Males are homozygous for the brown allele (**e**), whilst females are just hemizygous.

This variety is homozygous and, therefore, does not produce any other results when mated.

7.2 Barred Chocolate

Male (Bb ee):

Fig. 80: Barred Chocolate Male by Ashely Ford (Fords Farm)

Barred Chocolate is a split-based variety. They carry one copy of the black (**B**) and either a **b** or **b'** allele.

Due to their heterozygosity, breeding this variety leads to three different results.

7.3 Blue Calico

Male (b'b' cgcg Dd nn Rr):

Fig. 81: Blue Calico Male by Kaitlyn Eichelberger

Blue Calico is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**), one copy of the dom. slate (**D**) and one copy of the red allele (**r)**. Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to nine different results.

7.4 Blue Narragansett

Male (bb Dd nn):

Fig. 82: Blue Narragansett Male by Theodore Sours

Blue Narragansett is a bronze-based variety (**b**). They carry one copy of the dom. slate allele (**D**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to three different results.

7.5 Blue Palm

*Male (***b'b' cgcg Dd nn***):*

Fig. 83: Blue Palm Male

Blue Palm is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**) and one copy of dom. slate allele (**D**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to three different results.

*Female (**b’b’ cgcg Dd n-**):*

Fig. 84: Blue Palm Female

*Day old poult (**b’b’ cgcg Dd n-**):*

Fig. 85: Blue Palm Poult

Ten weeks old poult:

Fig. 86: Ten weeks old Blue Palm

Transition from juvenile to adult plumage.

7.6 Blue Red Bronze

Male (bb Dd Rr):

Fig. 87: Blue Red Bronze Male by Valeria Lutsko

Blue Red Bronze is a bronze-based variety (**b**). They carry one copy of the dom. slate (**D**) and one of the red allele (**r**).

Due to their heterozygosity, breeding this variety leads to nine different results.

Female (bb Dd Rr):

Fig. 88: Blue Red Bronze Female

Four days old (bb Dd Rr):

Fig. 89: Blue Red Bronze Poult by Kevin Porter (Porter's Rare Heritage Turkeys)

7.7 Blue Sweetgrass

Male (b'b' cgcg Dd):

Fig. 90: Blue Sweetgrass Male

Blue Sweetgrass is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**) and one copy of dom. slate allele (**D**).

Due to their heterozygosity, breeding this variety leads to three different results.

Female (b'b' cgcg Dd):

Fig. 91: Blue Sweetgrass Female

Day old poult (b'b' cgcg Dd):

Fig. 92: Blue Sweetgrass Poult

7.8 BLUE RED CORNISH PALM

Male (b'b' Ccg Dd Rr):

Fig. 93: Blue Red Cornish Palm Male

Blue Red Cornish Palm is a BWB-based variety (**b'**). They carry one copy of the gray (**cg**), one of dom. slate (**D**) and one of the red allele (**r**).

Due to their heterozygosity, breeding this variety leads to 27 different results.

7.9 Bourbon Buff

Male (bb nn rr):

Fig. 94: Bourbon Buff by Charlotte Anderson

Female (bb n- rr):

Fig. 95: Bourbon Buff Female

7.10 Bourbon Red

Male (bb rr):

Fig. 96: Bourbon Red Male by Bret Parlee

Bourbon Red is a bronze-based variety (**b**). They carry two copies of the red allele (**r**).

This variety is homozygous and, therefore, does not produce any other results when mated.

Female (bb rr):

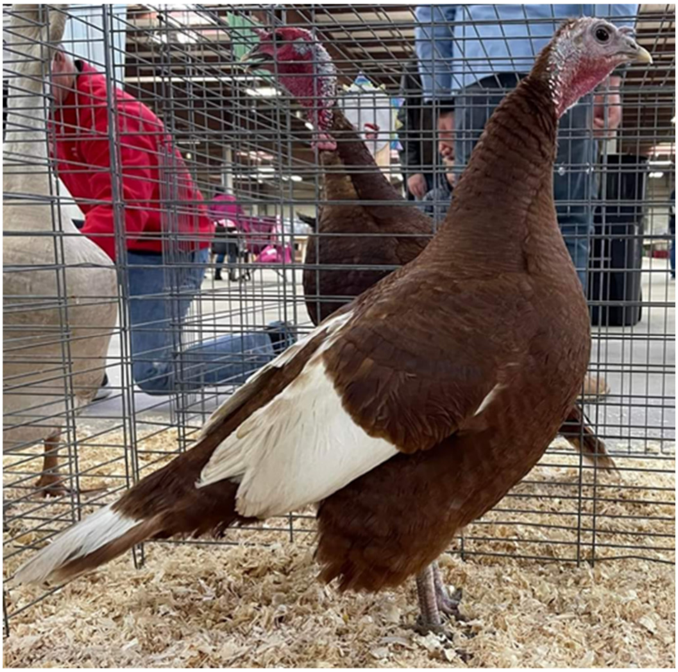


Fig. 97: Bourbon Red Female by Michelle Lee

4 days old poult:

Fig. 98: Bourbon Red Poults by Kevin Porter (Porter's Rare Heritage Turkeys)

7.11 Calico

Puter (b'b' cgcg nn Rr):

Fig. 99: Calico Male by Michael Edsel

Calico is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**) and one copy of the red allele (**r**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to three different results.

7.12 Chocolate

Male (BB ee):

Fig. 100: Chocolate Male by Kevin Porter (Porter's Rare Heritage Turkeys)

Female (BB e-)

Fig. 101: Chocolate Female by Morning Star Heritage Farm

7.13 Chocolate Slate

Male (BB Dd ee):

Fig. 102: Chocolate Slate Male by Kevin Porter (Porter's Rare Heritage Turkeys)

Chocolate Slate is a black-based variety (**B**). Both sexes carry one dom. slate allele (**D**). Males are homozygous for the brown allele (**e**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to three different results.

Female (BB Dd e-):

Fig. 103: Chocolate Slate Female by Kevin Porter (Porter's Rare Heritage Turkeys)

Poult (BB Dd ee):

Fig. 104: Chocolate Slate Poult by Kevin Porter (Porter's Rare Heritage Turkeys)

7.14 Chocolate Palm

Male (b'b' cgcg ee nn):

Fig. 105: Chocolate Palm Male by Karen Vaillancourt

Chocolate Palm is a BWB-based variety (**b'**). Both sexes carry two copies of the gray allele (**cg**). Males are homozygous for the brown (**e**) and Narragansett allele (**n**), whilst females are just hemizygous.

This variety is homozygous and, therefore, does not produce any other results when mated.

7.15 Chocolate Sweetgrass

Male (b'b' cgcg ee):

Fig. 106: Chocolate Sweetgrass Male by Marlene Juneau

Chocolate Sweetgrass is a BWB-based variety (**b'**). Both sexes carry two copies of the gray allele (**cg**). Males are homozygous for the brown allele (**e**), whilst females are just hemizygous.

This variety is homozygous and, therefore, does not produce any other varieties.

7.16 Dark Blue

Male (bb cgcg Dd nn):

Fig. 107: Dark Blue Male

Dark Blue is a bronze-based variety (**b**). They carry two copies of the gray (**cg**) and one copy of dom. slate allele (**D**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to three different results.

Female (bb cgcg Dd n-):

Fig. 108: Dark Blue Female

Feather Pattern:

Fig. 109: Dark Blue – Tail Pattern

7.17 Dark Gray

Male (bb cgcg nn):

Fig. 110: Dark Gray Male by Amanda Marie

Dark Gray is a bronze-based variety (**b**). They carry two copies of the gray allele (**cg**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

This variety is homozygous and, therefore, does not produce any other results when mated.

7.18 Dilute Rusty Slate

Male (Bb cgcg Dd nn Rr):

Fig. 111: Dilute Rusty Slate Male by Gerado Chaves

Dilute Rusty Slate is a split-base variety. They carry a black (**B**) and a bronze allele (**b**). In addition to that, they also carry two copies of the gray (**cg**), one copy of dom. slate (**D**) and one copy of the red allele (**r**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to 27 different results.

7.19 Fall Fire

Male (b'b' cgcg Rr):

Fig. 112: Fall Fire Male by Veronica Pelot

Female (b'b' cgcg Rr):

Fig. 113: Fall Fire Female by Tony Van Buren

7.20 Golden Narragansett

Male (bb nn Rr):

Fig. 114: Golden Narragansett Male by Kevin Porter (Porter's Rare Heritage Turkeys)

Female (bb n- Rr):

Fig. 115: Golden Narragansett Female by Valeria Lutsko

7.21 Golden Pencilled Palm

Male (b'b' cgcg nn pnpn Rr):

Fig. 116: Golden Pencilled Palm Male

Golden Pencilled Palm is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**), two of the pencilling (**pn**) and one copy of the red allele (**r**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to three different results.

Female (b'b' cgcg n- pnpn Rr):

Fig. 117 Golden Pencilled Palm Female

Day old poult (b'b' cgcg n- pnpn Rr):

Fig. 118: Day Old Golden Pencilled Palm Poult

10 weeks old (b’b’ cgcg n- pnpn Rr):

Fig. 119: Golden Pencilled Palm – 10 Weeks Old

Transition from juvenile to adult plumage.

7.22 Harvest Gold

Male (b’b’ Rr):

Fig. 120: Harvest Gold Male by Kevin Porter (Porter's Rare Heritage Turkeys)

Female (b’b’ Rr):

Fig. 121: Harvest Gold Female by Kevin Porter (Porter's Rare Heritage Turkeys)

7.23 Harvey Speckled

Male (bb rr **):

Fig. 122: Harvey Speckled Male

Harvey Speckled is a bronze-based variety (**b**). They carry two copies of the red allele (**r**). The rest of the genotype is still unknown and subject to further investigation.

This variety is homozygous and, therefore, does not produce any other results when mated.

*Female (bb rr **):*

Fig. 123: Harvey Speckled Female

*Day old poult (bb rr **):*

Fig. 124: Day Old Harvey Speckled

7.24 Jersey Buff

Male (BB rr):

Fig. 125: Jersey Buff Male by Maryse Gaston

Jersey Buff is a black-based variety (**B**). In addition, they carry two copies of the red allele (**r**).

This variety is homozygous and, therefore, does not produce any other results when mated.

7.25 Marbled Slate

Male (BB cgcg Dd nn):

Fig. 126: Marbled Slate Male by Liz Martin Rodriguez

Female (BB cgcg Dd n-):

Fig. 127: Marbled Slate Female

7.26 Mottled Chocolate

Male (Bb’ cgcg ee nn):

Fig. 128: Mottled Chocolate Male by Kevin Porter (Porter's Rare Heritage Turkeys)

Female (Bb’ cgcg e- n-):

Fig. 129: Mottled Chocolate Female by Kevin Porter (Porter’s Rare Heritage Turkeys)

7.27 Mottled Chocolate Dapple

Male (Bb' cgc ee nn):

Fig. 130: Mottled Chocolate Dapple Male by Fall Fire Farm

Female (Bb' cgc e- n-):

Fig. 131: Mottled Chocolate Dapple Female by Fall Fire Farm

7.28 Mottled Black

Male (Bb’ cgcg nn):

Fig. 132: Mottled Black Male

Mottled Black is a split-base variety. They carry a black (**B**) and a BWB allele (**b’**). Both sexes carry two copies of the gray allele (**cg**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to three different results.

Female (Bb' cgcg n-):

Fig. 133: Mottled Black Female

Day old poult (Bb' cgcg nn):

Fig. 134: Day Old Mottled Black

Fig. 135: Mottled Black Feathers

The feather pattern of Mottled Black and all mottled varieties, in general can vary a lot. Some feathers will reveal the BWB background, while others will remain pure black. The number of palm-like feathers will increase with every moult. After a few years, such a Mottled Black can end up with a 50/50 black and white phenotype.

7.29 Mottled Slate

Male (Bb’ cgcg Dd nn):

Fig. 136: Mottled Slate Male by Fall Fire Farm

Female (Bb’ cgcg Dd n-):

Fig. 137: Mottled Slate Female by Fall Fire Farm

7.30 Narragansett (Black)

aka Silver-Tipped Black

Male (BB nn):

Fig. 138: Silver-Tipped Black Male by Tracey Smallz

Silver-Tipped Black is a black-based variety (**B**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

This variety is homozygous and, therefore, does not produce any other results when mated.

Fig. 139 Feathers of a Silver-Tipped Black (BB nn).

Other than in Black turkeys, Silver-Tipped Blacks do have white feather edges on the lower back. This is due to the effect of the Narragansett gene, which reduces the reddish-brown pigmentation.

Fig. 140: Lower Back of a Black (BB) turkey.

7.31 Narragansett (Black-Winged Bronze)

aka Black-Winged Narragansett

Male (b’b’ nn):

Fig. 141: Black-Winged Narragansett Male by Daryl Deutscher

Black-Winged Narragansett is a BWB-based variety (**b’**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

This variety is homozygous and, therefore, does not produce any other results when mated.

Female (b'b' n-):

Fig. 142: Black-Winged Narragansett Female

Ten weeks old poult (b'b' n-):

Fig. 143: Ten Weeks Old Black-Winged Narragansett

7.32 Narragansett (Bronze)

Male (bb nn):

Fig. 144: Bronze Male by Jens Hörl

Narragansett is a bronze-based variety (**b**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

This variety is homozygous and, therefore, does not produce any other results when mated.

Female (bb n-):

Fig. 145: Narragansett Female

Feather Detail:

Fig. 146: Feather Detail - Narragansett

7.33 OREGON BLUE

Male (bb cgc nn Dd):

Fig. 147: Oregon Blue Male

Oregon Blue is a bronze-based variety (**b**). They carry one copy of the gray (**cg**), one of the white (**c**) and one of the dom. slate allele (**D**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to seven different results.

Female (bb cgc n- Dd):

Fig. 148: Oregon Blue Female

Day old poult (bb cgc nn Dd):

Fig. 149: Day Old Oregon Blue

Fig. 150: Oregon Blue Feather

The primary wing feathers appear almost white with just a slight grayish veil.

As in all heterozygous dominant blue varieties (**D**), some black leakage can be found in certain areas of the plumage.

Fig. 151: Oregon Blue Tail Detail

The tail pattern is similar to those of a Blue Palm. A broad blue band adorns the otherwise almost white tail. A small residue of grayish pigments will still remain.

7.34 Painted

Male:

Fig. 152: Painted Male by Daryl Deutscher

This variety originates to Australia, where Daryl Deutscher first created them. He still breeds many different variations of this variety till today.

Unfortunately, not much is known about their genetic background. Research is still ongoing. The mutation present in this variety causes a massive reduction in feather pigmentation, leading to this unique pattern.

Female:

Fig. 153: Painted Female by Daryl Deutscher

Day old poults:

Fig. 154: Day Old Painted Poults by Daryl Deutscher

7.35 Pencilled Blue Fall Fire

Male (b’b’ cgcg pnpn Dd Rr):

Fig. 155: Pencilled Blue Fall Fire Male

Pencilled Blue Fall Fire is a BWB-based variety (**b’**). They carry two copies of the gray (**cg**), two of the pencilling (**pn**), one copy of dom. slate (**D**) and one of the red allele (**r)**.

Due to their heterozygosity, breeding this variety leads to nine different results.

Female (b'b' cgcg pnpn Dd Rr):

Fig. 156: Pencilled Blue Fall Fire Female

Day old poult (b'b' cgcg pnpn Dd Rr):

Fig. 157: Day Old Pencilled Blue Fall Fire Poult

10 weeks old (b'b' cgcg pnpn Dd Rr):

Fig. 158: Ten Weeks Old Pencilled Blue Fall Fire

Transition from juvenile to adult plumage.

Fig. 159: Pencilled Blue Fall Fire Feather

Fig. 160: Pencilled Blue Fall Fire - Lower Back

7.36 Pencilled Blue Palm

Male (b'b' cgcg Dd nn pnpn):

Fig. 161: Pencilled Blue Palm Male

Pencilled Blue Palm is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**), two of the pencilling (**pn**) and one copy of dom. slate allele (**D**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to three different results.

Female (b’b’ cgcg Dd nn pnpn):

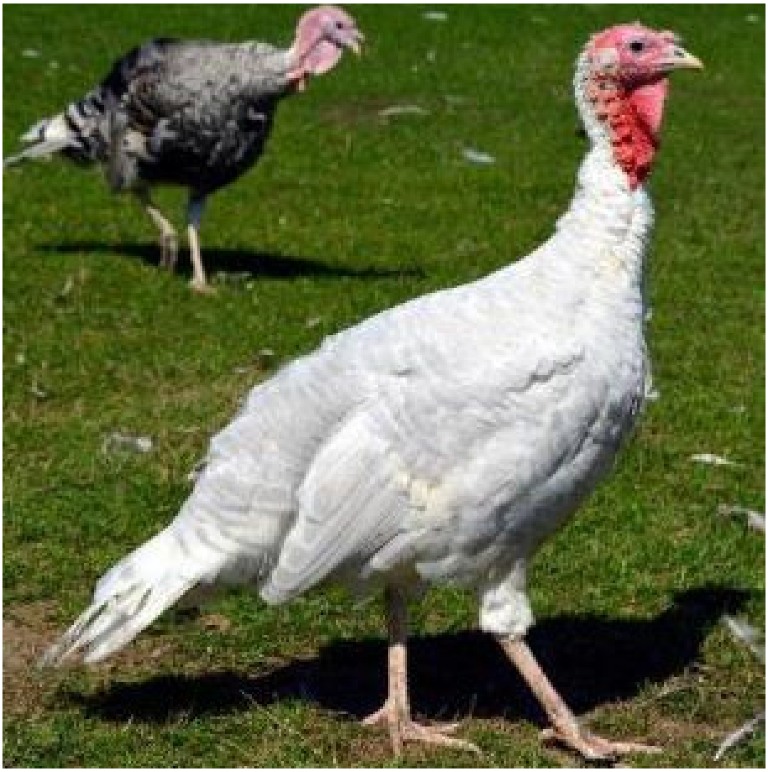


Fig. 162: Pencilled Blue Palm Female

Day old poult (b’b’ cgcg Dd nn pnpn):

Fig. 163: Day Old Pencilled Blue Palm

Ten weeks old poult:

Fig. 164: Ten Weeks Old Blue Pencilled Palm

Transition from juvenile to adult plumage.

7.37 Pencilled Blue Sweetgrass

Male (b'b' cgcg Dd pnpn):

Fig. 165: Pencilled Blue Sweetgrass Male by Eva Maria Wagner

Pencilled Blue Sweetgrass is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**), two of the pencilling (**pn**) and one copy of the dom. slate allele (**D**).

Due to their heterozygosity, breeding this variety leads to three different results.

Female (b'b' cgcg Dd pnpn):

Fig. 166: Pencilled Blue Sweetgrass Female

Feather Pattern:

Fig. 167: Wing Detail

Ten weeks old (b'b' cgcg Dd pnpn):

Fig. 168: Ten Weeks Old Pencilled Blue Sweetgrass

Transition from juvenile to adult plumage.

7.38 Pencilled Fall Fire

Male (b’b’ cgcg pnpn Rr):

Fig. 169: Pencilled Fall Fire Male

Pencilled Fall Fire is a BWB-based variety (**b’**). They carry two copies of the gray (**cg**), two of the pencilling (**pn**) and one copy of the red allele (**r)**.

Due to their heterozygosity, breeding this variety leads to three different results.

Female (b'b' cgcg pnpn Rr):

Fig. 170: Pencilled Fall Fire Female

Feather Pattern:

Fig. 171: Wing Detail

Ten weeks old (b'b' cgcg pnpn Rr):

Fig. 172: Ten Weeks Old Pencilled Fall Fire

Transition from juvenile to adult plumage.

7.39 Pencilled Lavender Sweetgrass

Female (b’b’ cgcg DD pnpn):

Fig. 173: Pencilled Lavender Sweetgrass

Day old (b’b’ cgcg DD pnpn):

Fig. 174: Day Old Pencilled Lavender Sweetgrass

Ten weeks old (b'b' cgcg DD pnpn):

Fig. 175: Ten Weeks Old Pencilled Lavender Sweetgrass

Transition from juvenile to adult plumage.

7.40 Black-Winged Narragansett (semi-Pencilled / Semi-Gray)

Male (b'b' Ccg nn Pnpn):

Fig. 176: Black-Winged Narragansett (Semi-Pencilled / Semi-Gray) Male

Black-Winged Narragansett (semi-pencilled/semi-gray) is a BWB-based variety (**b'**). They carry one copies of the gray (**cg**) and one of the pencilling allele (**pn**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

Due to their heterozygosity, breeding this variety leads to three different results.

Female (b'b' Ccg n- Pnpn):

Fig. 177: Black-Winged Narragansett (Semi-Pencilled / Semi-Gray) Female

Poult (b'b' Ccg nn Pnpn):

Fig. 178: Black-Winged Narragansett (Semi-Pencilled / Semi-Gray) Poult

7.41 Pencilled Palm

Male (b'b' cgcg nn pnpn):

Fig. 179: Pencilled Palm Male

Pencilled Palm is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**) and two of the pencilling allele (**pn**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

This variety is homozygous and, therefore, does not produce any other results when mated.

Female (b’b’ cgcg n- pnpn):

Fig. 180: Pencilled Palm Female

Day old (b’b’ cgcg nn pnpn):

Fig. 181: Day Old Pencilled Palm

7.42 Pencilled Palm (Semi-White)

Female (b'b' cgc n- pnpn):

Fig. 182: Pencilled Palm (Semi-White) Female

Feather Pattern:

Fig. 183: Shoulder Detail

7.43 Pencilled Red Palm

Male (b'b' cgcg nn pnpn rr):

Fig. 184: Pencilled Red Palm Male by Rejean Girard

Pencilled Red Palm is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**), the pencilling (**pn**) and red allele (**r**).

This variety is homozygous and, therefore, does not produce any other results when mated.

Female (b'b' cgcg n- pnpn rr):

Fig. 185: Pencilled Red Palm Female

Day old poult (b'b' cgcg nn pnpn rr):

Fig. 186: Day Old Pencilled Red Palm

Ten weeks old (b'b' cgcg nn pnpn rr):

Fig. 187: Ten Weeds Old Pencilled Red Palm

Transition from juvenile to adult plumage.

7.44 Pencilled Sweetgrass

Male (b'b' cgcg pnpn):

Fig. 188: Pencilled Sweetgrass Male

Pencilled Sweetgrass is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**) and pencilling allele (**pn**).

This variety is homozygous and, therefore, does not produce any other results when mated.

Female (b'b' cgcg pnpn):

Fig. 189: Pencilled Sweetgrass Female

Day old (b'b' cgcg pnpn):

Fig. 190: Day Old Pencilled Sweetgrass

Ten weeks old (b'b' cgcg pnpn):

Fig. 191: Ten Weeks Old Pencilled Sweetgrass

Transition from juvenile to adult plumage.

7.45 RECESSIVE BLUE PENCILLED PALM

Male (b'b' cgcg nn slsl):

Fig. 192: Recessive Blue Pencilled Palm Male by Sue Wiltshire

Tail Feathers:

Fig. 193: Tail Detail by Sue Wiltshire

7.46 Recessive Blue Sweetgrass

Male (b'b' cgcg slsl):

Fig. 194: Recessive Blue Sweetgrass Male by Sue Wiltshire

Recessive Blue Sweetgrass is a BWB-based variety (**b'**). They carry two copies of the gray (**cg**) and rec. slate allele (**sl**).

This variety is homozygous and, therefore, does not produce any other results when mated.

7.47 Recessive Lilac

Male (bb slsl rr):

Fig. 195: Recessive Lilac Male by Daryl Deutscher

Poults (bb slsl rr):

Fig. 196: Recessive Lilac Poults by Daryl Deutscher

7.48 Recessive Slate

Male (bb slsl):

Fig. 197: Recessive Slate Male by Lydie Čajková Pecháčková

Recessive Slate is a bronze-based variety (**b**). They carry two copies of the rec. slate allele (**sl**).

This variety is homozygous and, therefore, does not produce any other results when mated.

Females (bb slsl):

Fig. 198: Recessive Slate Females by Pasi Hellstén

Wing Detail:

Fig. 199: Wing Detail - Recessive Slate by Lydie Čajková Pecháčková

Unlike individuals with a dominant slate gene (**D**), recessive slates show a clear barring in the flight feathers.

7.49 Red Bronze

Male (bb Rr):

Fig. 200: Red Bronze Male by Michael Kümpel

Red Bronze is a bronze-based variety (**b**). They carry one copy of the red allele (**r)**.

Due to their heterozygosity, breeding this variety leads to three different results.

Female (bb Rr):

Fig. 201: Red Bronze Female

Five days old (bb Rr):

Fig. 202: Five Days Old Red Bronze

7.50 Red Lilac

Male (BB rr slsl):

Fig. 203: Red Lilac Male

Red Lilac is a black-based variety (**B**). In addition, they carry two copies of the red (**r**) and rec. slate allele (**sl**).

This variety is homozygous and, therefore, does not produce any other results when mated.

Female (BB rr slsl):

Fig. 204: Red Lilac Female by Daryl Deutscher

Day old (BB rr slsl):

Fig. 205: Red Lilac Poult by Daryl Deutscher

7.51 Red Slate

Male (bb Dd):

Fig. 206: Red Slate Male by Eva Maria Wagner

Red Slate is a bronze-based variety (**b**). They carry one copy of the dom. slate allele **(D)**.

Due to their heterozygosity, breeding this variety leads to three different results.

Female (bb Dd):

Fig. 207: Red Slate Female

Day old (bb Dd):

Fig. 208: Day Old Red Slate

Feather Pattern:

Fig. 209: Feather Detail

Fig. 210: Black leakage in the slated areas

7.52 Red Sweetgrass

Male (b'b' cgcg rr):

Fig. 211: Red Sweetgrass Male by Fran Hogan

Female (b'b' cgcg rr):

Fig. 212: Red Sweetgrass Female by Fall Fire Farm

7.53 Regal Red

Male (b'b' rr):

Fig. 213: Regal Red Male by Jens Hörl

Regal Red is a BWB-based variety (**b'**). They carry two copies of the red allele (**r**).

This variety is homozygous and, therefore, does not produce any other results when mated.

Female (b'b' rr):

Fig. 214: Regal Red Female by Jens Hörl

Day old (b'b' rr):

Fig. 215: Day Old Regal Red Poults by Jens Hörl

7.54 ROYAL PALM

Male (b'b' cgcg nn):

Fig. 216: Royal Palm Male

Royal Palm is a BWB-based variety (**b'**). They carry two copies of the gray allele (**cg**). Males are homozygous for the Narragansett allele (**n**), whilst females are just hemizygous.

This variety is homozygous and, therefore, does not produce any other results when mated.

Female (b'b' cgcg n-):

Fig. 217: Royal Palm Female

Day old (b'b' cgcg nn):

Fig. 218: Day Old Royal Palm

7.55 Royal Palm (Semi-White)

Female (b’b’ cgc n-):

Fig. 219: Royal Palm (Semi-White) Female

Comparison:

Fig. 220: Royal Palm (top), Royal Palm Semi-White (bottom)

7.56 Rusty Dapple

Male (Bb cgc Rr nn):

Fig. 221: Rusty Dapple Male

Feather Detail:

Fig. 222: Primary flight feather of a Rusty Dapple

Female (Bb cgc Rr n-):

Fig. 223: Rusty Dapple Female

Day old (Bb cgc Rr nn):

Fig. 224: Day Old Rusty Dapple

7.57 Self Blue

Male (BB DD):

Fig. 225: Self Blue Male by Andreas Gruber

Self Blue is a black-based variety (**B**). They carry two copies of the dom. slate allele (**D**).

This variety is homozygous and, therefore, does not produce any other results when mated.

7.58 Self Buff

Male (b'b' ee nn rr)

Fig. 226: Self Buff Male by Marcia Lincoln

Female (b'b' e- n- rr):

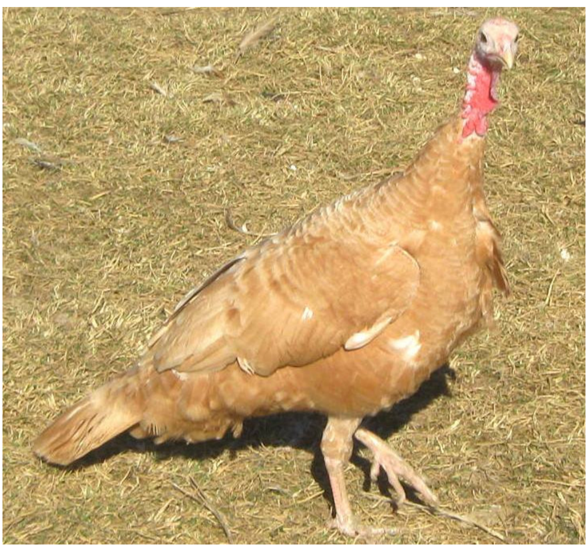


Fig. 227: Self Buff Female by Kevin Porter (Porter's Rare Heritage Turkeys)

7.59 Slate

Male (BB Dd):

Fig. 228: Slate Male by Valeria Lutsko

Slate is a black-based variety (**B**). They carry one copy of the dom. slate allele (**D**).

Due to their heterozygosity, breeding this variety leads to three different results.

Female (BB Dd):

Fig. 229: Slate Female by Marcia Lincoln

Day old (BB Dd):

Fig. 230: Day Old Slate Poult

7.60 Sweetgrass

Male (b'b' cgcg) – light version:

Fig. 231 Light Sweetgrass Male by Pasi Hellstén

Female (b'b' cgcg) – light version:

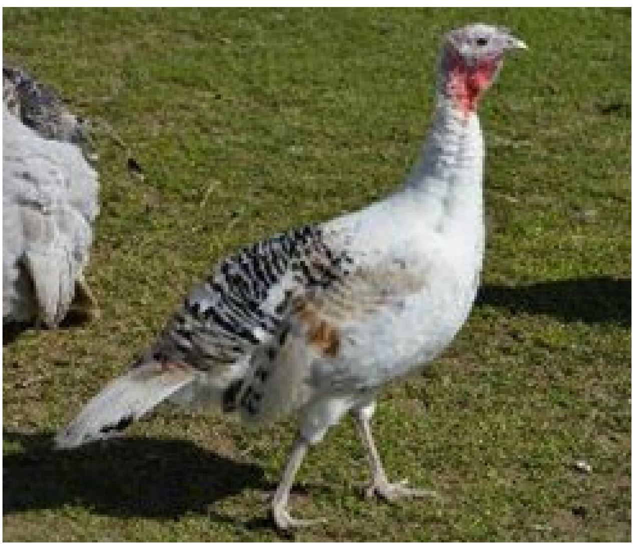


Fig. 232: Light Sweetgrass Female

Male (b'b' cgcg) - dark version:

Fig. 233: Dark Sweetgrass Male by Sue Wiltshire

Female (b'b' cgcg) - dark version:

Fig. 234: Dark Sweetgrass Female by Sue Wiltshire

7.61 Tri Color Mottled Black

Male (Bb' cgcg):

Fig. 235: Tri Color Mottled Black Male

Tri Color Mottled Black is a split-base variety. They carry a black (**B**) and a BWB allele (**b'**). Both sexes carry two copies of the gray allele (**cg**).

Due to their heterozygosity, breeding this variety leads to three different results.

Female (Bb' cgcg):

Fig. 236: Tri Color Mottled Black Female

Day old (Bb' cgcg):

Fig. 237: Day Old Tri Color Mottled Black

7.62 Tri Color Mottled Slate

Male (Bb' cgcg Dd):

Fig. 238: Tri Color Mottled Slate Male by Sara Richardson J L bar farm

Tri Color Mottled Slate is a split-base variety. They carry a black (**B**) and a BWB allele (**b'**). Both sexes carry two copies of the gray (**cg**) and one copy of the dom. slate allele (**D**).

Due to their heterozygosity, breeding this variety leads to nine different results.

Fig. 239: Black Speckles are bleeding through the slate color.

Fig. 240: Some single Blue Sweetgrass feathers can be spotted

Tri Color Mottled Slates will express the pattern of both base base color genes. The number of feathers with a Blue Sweetgrass pattern will increase with every moult.

7.63 White

*Male (** cc):*

Fig. 241: White Male by Heather Barlow

White can be produced on any base color. They carry two copies of the white allele (**c**).

This variety is homozygous and, therefore, does not produce any other results when mated.

*Female (** cc):*

Fig. 242: White Female

Day old poult (bb cc):

Fig. 243: Day Old White Poult (Bronze-Based)

In turkeys, males and females do have different visual characteristics, called sexual dimorphism. The most obvious difference is in height and weight. Males grow much taller and weigh about 50% more than females do. These differences can already be recognized in individuals of just a couple of weeks of age.

Fig. 244: Male (left) – Female (right)

Fig. 245: Male (left) – Female (right)

The length and thickness of the legs is also a good indicator for the sex. Males have much longer and thicker legs than their female counterparts.

Fig. 246: Male (left) – Female (right)

Where pigmentation is concerned, the breast feathers are a good indicator for the sex of the individual. While males tend to have dark edges on every feather, females do have white or lighter colored tips.

Fig. 247: Male (left) – Female (right)

The head of a turkey also enables us to distinguish between the sexes. Snood, wattle, and caruncles differ in size and form. While males have long snoods, a big wattle, and caruncles, females have short snoods, small wattles, and caruncles. Male turkeys are also marked by bald heads, while females have feathers on their heads and necks.

9 POULT COLORING

As in most birds, turkeys also go through several phases of coloring. In these phases, the differences between the different varieties can be quite huge. Therefore it is of the utmost importance to interpret these differences in the correct way to determine the underlying genetics.

Even with modifying genes at work, most of the time it is possible to determine at least some certain aspects of the genome.

The most obvious difference exists in the down color between the different base color mutations.

9.1.1 Bronze (b):

In general, bronze turkeys have a reddish-brown down color with black markings on the back and head. Even in Bronze-based Whites, these reddish-brown tones can be determined. With modifying genes, the color of the markings and the general intensity of the coloration can be changed.

		
bb Rr	**bb cgc Dd nn**	**bb cc**

9.1.2 Black (B):

Backs are the easiest to identify. They have a dark face mask and a uniform coloration. This face mask can sometimes also be spotted in Black-based whites.

		
Bb cgcg nn	**Bb cgcg Dd nn**	**BB cc**

9.1.3 Black-Winged Bronze (b’):

Black-Winged Bronze does have a yellow down color with black markings on their back and head. Some modifying genes can cause the markings to completely vanish, like in **b’b’ cgcg nn** (Royal Palm).

		
b’b’ Ccg	**b’b’ cgcg pnpn**	**b’b’ cgcg Rr pnpn**

10 Curiosities

10.1 Dwarfism

Another fascinating phenomenon is dwarfism. Very little is known about the genetic background causing this condition. In turkeys, the most common form of dwarfism is proportionate dwarfism, where both the limbs and torso are unusually small. There seem to be no significant side effects of this mutation, like intelligence reduction or reduced life expectancy.

The most common bantam variety is the "Tacchino Bronzato dei Colli Euganei", which originates in Italy. These turkeys are usually bronze in color with a very yellowish skin coloration.

There are also reports from a wild flock of bantam turkeys living on King Island (Tasmania), where most likely natural selection was causing dwarfism.

Comparison:

Fig. 248: Bantam turkeys compared to a normal sized Bronze by Carl Augustinus.

Fig. 249: Dwarf turkey compared to English Sussex chicken by Guillaume Durand (Les Petites Plumes du Quercy)

Euganean Turkeys:

Fig. 250: Euganean turkeys with yellow skin color by Christian Scholz

10.2 Hairy feathering

ha (hairy feathering) / **Ha** (non-hairy feathering)

Hairy feathering (**ha**) is a mutation that influences the feather structure. This mutation causes an unusual, hairy look of the feathers. Instead of normal feather webbing, the individual feathers appeared to have short thick hair attached to the rachis.

Male (b'b' cgcg nn haha):

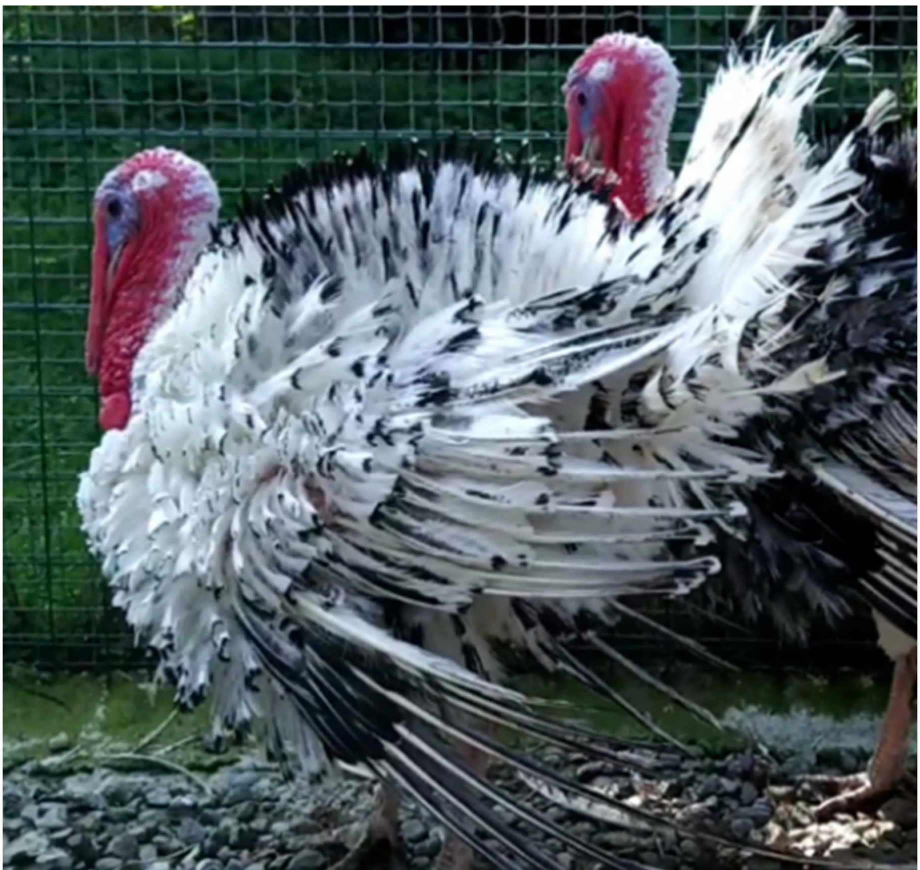


Fig. 251: Hairy Feathering by Michele Rocco

Tail Detail (b'b' cgcg nn haha):

Fig. 252: Tail Detail - Hairy Feathering by Michele Rocco

Abnormal feather webbing can be observed throughout the whole plumage.

10.3 CRESTING

cr (crested) / **Cr** (non-crested)

Another extremely rare mutation is **cr**. This mutation causes turkeys to develop a crest. No living individual with this allele is currently known.

Male (bb nn crcr):

Fig. 253: Natural History Museum in Parma. Picture by Alessio Zanon.

Painting:

Fig. 254: UK Birmingham Poultry Show 1870.

10.4 Mosaic

There are several known cases of lateral asymmetry in the domestic fowl. Their occurrence is very rare, as this trait is not inheritable. These cases can vary a lot. In some cases, one side of the offspring resembles the color pattern of the sire, while the other side resembles those of the mother; in other cases the only apparent difference is in the skin color or the shank color of one side (ASMUNDSON, 1937).

10.4.1 Bronze-Narragansett Mosaic

Fig. 255: Bronze-Narragansett Mosaic by Christy Secondino

Fig. 256: Side Detail - Bronze-Narragansett Mosaic by Christy Secondino

10.4.2 Narragansett-Jersey Buff Mosaic

Fig. 257: Narragansett-Jersey Buff Mosaic by Aleksandra Gill

Fig. 258: Wing Detail - Narragansett-Jersey Buff Mosaic by Aleksandra Gill

Fig. 259: Side Detail - Narragansett-Jersey Buff Mosaic by Aleksandra Gill

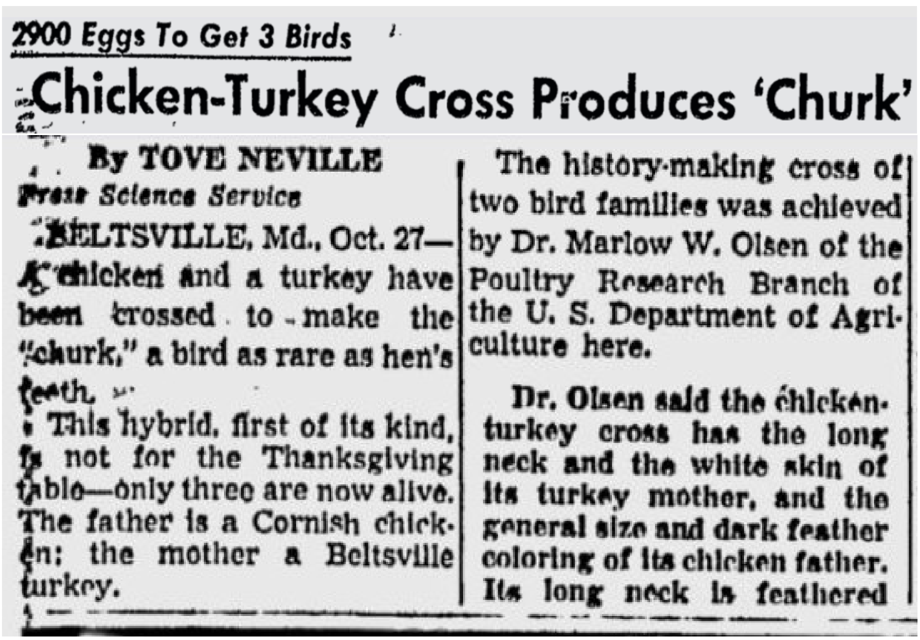
Fig. 260: Mosaic Turkey by Saverio Manetti (1723-1784)

10.5 Hybrids

As in other species, hybridization also occurs in turkeys.

More than 60 years ago, researchers at the Beltsville Agricultural Research Center engaged in some creative barnyard breeding. Their goal was the development of fatherless turkeys — virgin hens that would reproduce via parthenogenesis. Along the way, and ostensibly quite by accident, an interim stage of this work resulted in a rooster-fathered hybrid that the scientists called a Churk (Raloff, 2011).

10.5.1 The Churk



2900 Eggs To Get 3 Birds

Chicken-Turkey Cross Produces 'Churk'

By TOVE NEVILLE
Press Science Service

BELTSVILLE, Md., Oct. 27—A chicken and a turkey have been crossed to make the "churk," a bird as rare as hen's teeth.

This hybrid, first of its kind, is not for the Thanksgiving table—only three are now alive. The father is a Cornish chicken; the mother a Beltsville turkey.

The history-making cross of two bird families was achieved by Dr. Marlow W. Olsen of the Poultry Research Branch of the U. S. Department of Agriculture here.

Dr. Olsen said the chicken-turkey cross has the long neck and the white skin of its turkey mother, and the general size and dark feather coloring of its chicken father. Its long neck is feathered

Source 1: The Pittsburgh Press - Oct 27, 1960 but without wattles. Its legs are like those of a young turkey.

Dr. Olsen said it would not be practical to produce the hybrids commercially, since they are difficult to bring through the matching stage and keep alive. Some 2900 eggs were processed to produce the live birds.

All the "churks" have some defects, such as crooked legs or beaks. Another abnormality, Dr. Olsen said, is that the hybrid birds' feathers grow in a twist, probably because of unequal growth in the cells.

The hybrids are weak, Dr. Olsen said. They have only about half the intelligence of the parent stock. They are kept in a separate pen by themselves, because they would be picked to death if

mixed with other fowl, either chicken or turkey.

The "churk" is a silent bird. It has neither the "gobble, gobble" of the turkey parent nor the crowing of the rooster father. Dr. Olsen said it lets out a chirp something like a chicken, but only when it is disturbed.

The hybrids are all male birds, and unable to reproduce themselves. The reason for this is the different number of chromosomes in chickens (six pairs) and turkeys (nine pairs).

The hybrids got a single set of chromosomes from each parent (six from the chicken, nine from the turkey). Thus, they end up with 15 chromosomes that cannot pair up and produce offspring.

This means that a turkey and chicken would have to be cross-bred every time a hybrid is to be produced.

Source 2: The Pittsburgh Press - Oct 27, 1960

Cover “Science News Letter”:

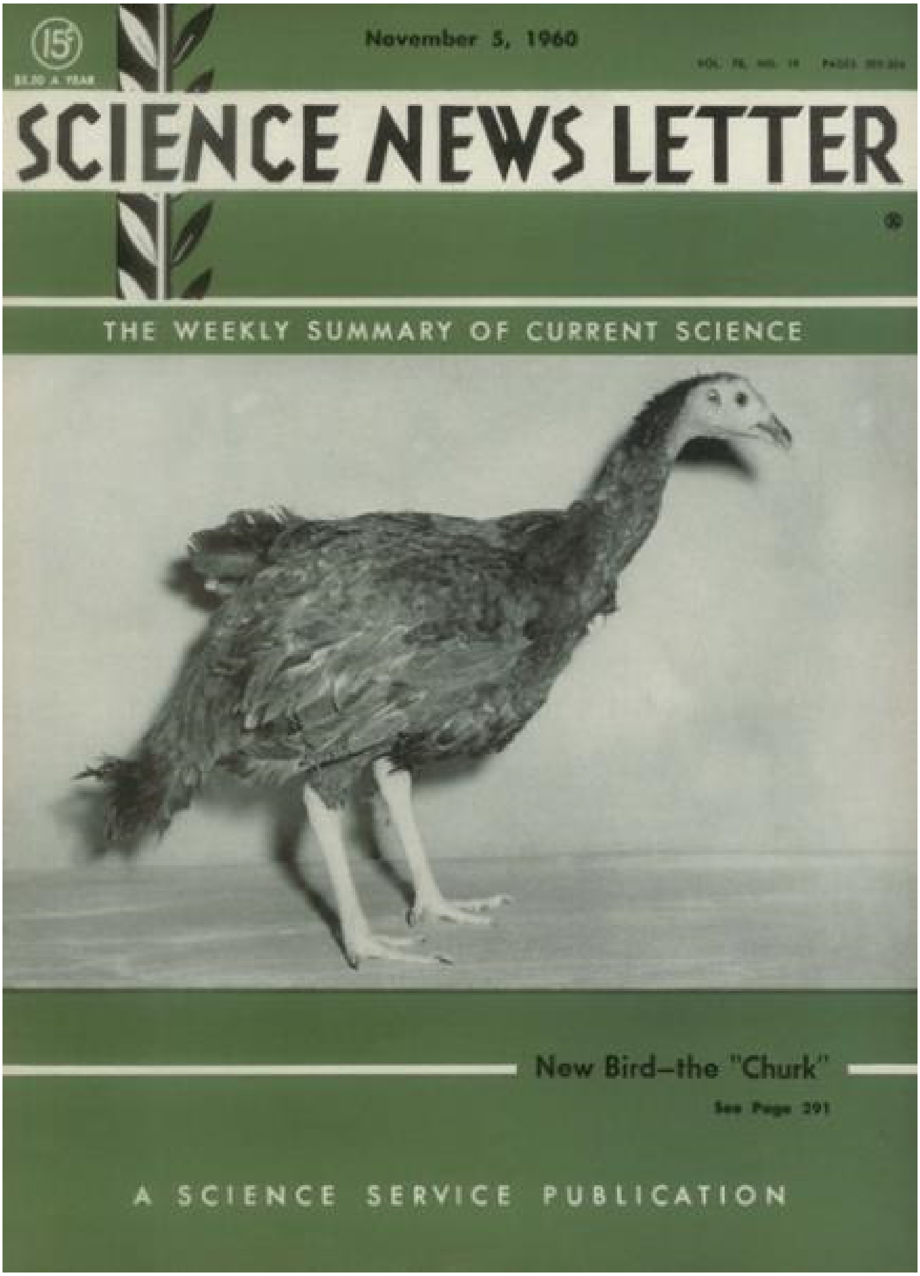


Fig. 261: Science News Letter from November 5, 1960 (Raloff, 2011)

Fig. 262: (Chicken-Turkey Cross Produced 'Churk', 1960)

Fig. 263: Four week old Turkey x Chicken hybrid

10.6 Ocellated Turkey

The Ocellated turkey is a species primarily found in the Yucatan Peninsula (Mexico), as well as parts of Belize and Guatemala. It's a close relative of the North American Wild turkeys (Meleagris gallopavo). Due to this close relation, both together can produce fertile offspring. The color genetics of this fabulous specimen aren't yet fully understood.

Fig. 264: by Tony Castro, distributed under a CC BY-SA 4.0 license

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