Moving on to Factor Seven -

Using Genetics to Breed Better Racing Pigeons

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Dixie Southern Racing Pigeon Association
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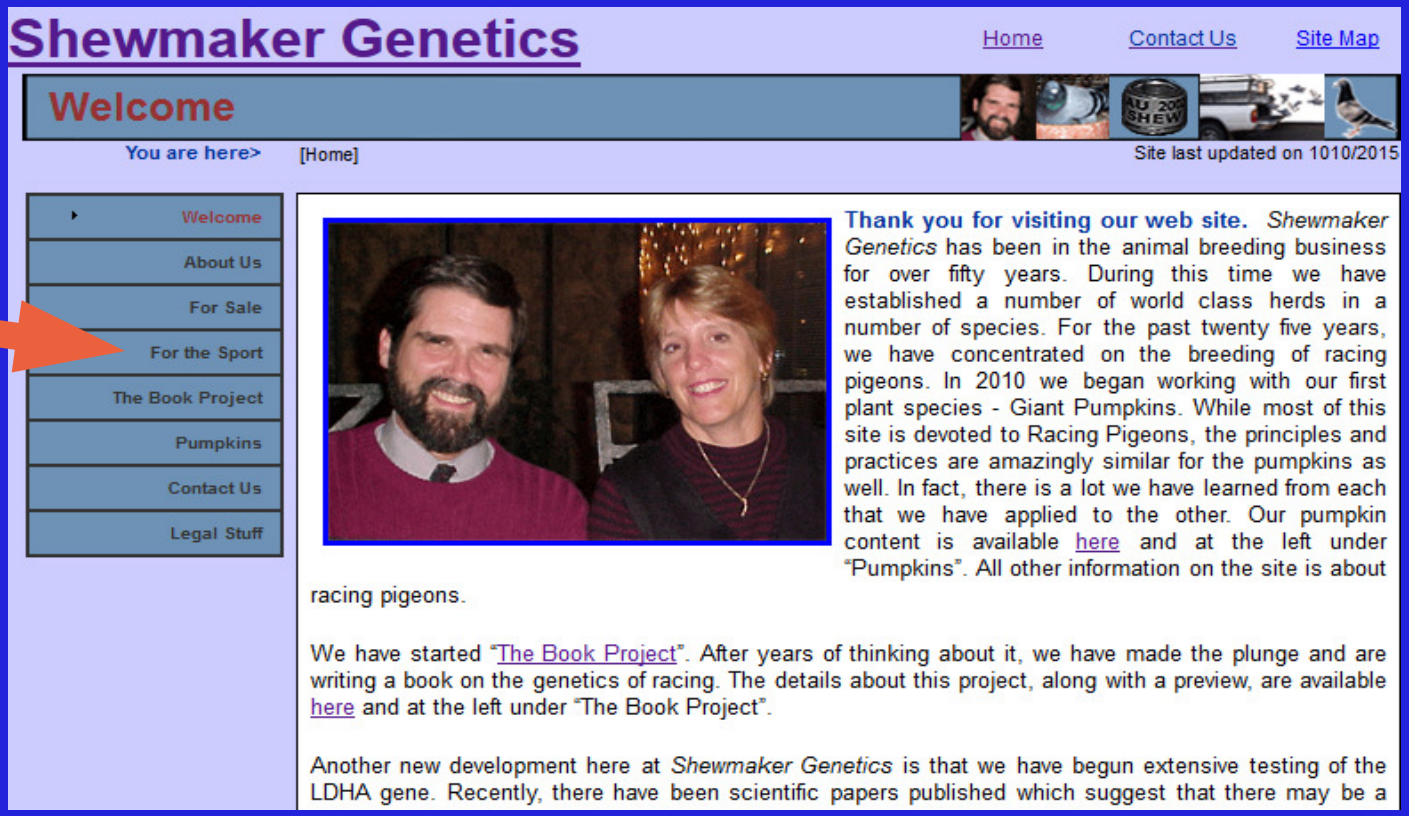
My Biases

- My degree is in genetics.
- I have been an animal breeder and consultant for over 50 years working with dozens of species including swine, cattle, sheep, horses, rabbits and racing pigeons.
- So I have strong opinions based on these two frames of reference.
- **I am here just to share and not to win converts** - you can and should do it any way you want.
- Pigeon Racing is a hobby – keep it relevant to what ***you*** enjoy.

Some Background Information

- My web site (www.shewmaker.com) has some additional information that you may find helpful in sorting out some of the ideas we are going to talk about today (Under the “For the Sport” tab).



The Rule of Seven

- There are seven factors which determine how well you and your birds will perform in pigeon racing.
- **One is beyond your control**.
- **Five are so well perfected within the sport that they have become essentially pass/fail.** You either cover them competently or you are virtually eliminated from the winning positions even before the race starts.
- **One has almost no limit** to its potential and is **largely unrealized** by most fanciers.

The Rule of Seven

1) Beyond our control – **luck**. Good luck, bad luck, hawks, wires, wind direction, basket position on the truck, bad weather along the course, good weather along the course when we entered a tough weather bird, and on and on and on. It affects us all and so we should just get over it and move on to what we can control.

2) **Condition** (pass/fail)

3) **Training** (pass/fail)

4) **Fuel** (pass/fail)

5) **Motivation** (pass/fail)

The Rule of Seven

6) **Health** (pass/fail though too many flyers are still failing on this one. We could have a week of seminars just on this topic alone.)

7) **Genetics**

When Louis Van Loon was asked “What methods do you use to get those kind of results?” he looked sternly at the gentleman and said, “Remember this, there is only one thing that is important – good pigeons, nothing else.”

Its Time to Move to Factor Seven

- Gregor Mendel's work was published in 1865 (that was 150 years ago!)
- Consider some of the other key discoveries or inventions of that era and their impact on us today:
  - 1861 Louis Pasteur – Germ Theory
  - 1873 James Maxwell – Theory of Electromagnetism
  - 1886 Benz & Daimler – First gasoline automobiles
  - 1898 Marie Curie – Polonium and Radium
  - 1905 Albert Einstein – Theory of Special Relativity

Its Time to Move to Factor Seven

- The science of genetics has made enormous progress since then:
  - 1952 Hershey/Chase - DNA is likely the genetic material
  - 1953 Watson & Crick – Structure of DNA
  - 1978 Genetech – Genetically engineered human insulin
  - 1986 First use of DNA in court proceedings
  - 2003 Complete map of the human genome
  - 2015 FDA approval of genetically modified virus for targeted cancer treatment

Its Time to Move to Factor Seven

- Yet many racing pigeon breeders today still struggle applying even the basic work of Mendel.
  - Some on the forums even question if Mendel's work applies to pigeon racing.

- Yes, it can be complex, but it doesn't have to be.
  - You don't have to know how to build a watch, to be able to use one to tell time.

Moving to Factor Seven

The three objectives of this seminar are to

1. Implore each of you to move on to that seventh factor of racing success, genetics

2. Provide you with a high level road map for making genetic improvement

3. Introduce you to an exciting new development, DNA testing for the LDHA gene

Simple Genetics

- Pigeons have 40 pairs of unique chromosomes for a total of 80 chromosomes.
- On the chromosomes, reside genes. You can think of them as being like beads on a string. The individual beads are the genes and a particular string of these genes is a chromosome.
- The genes are the precise blueprint for every trait of an individual.
- These traits range from what we can easily observe (like the color of the eye) to less discrete and intangible things like mental attitude.

Simple Genetics

- During fertilization, each parent contributes one chromosome of each the 40 pairs.
  - One of these pairs (the Sex Chromosomes W and Z) is unique in that the W chromosome contains no genes. Cocks are ZZ and hens are WZ. So for a small number of genes (1/40th or 2.5%) hens did not receive a contribution from their mother. These are referred to as “sex linked traits”.
  - I do not subscribe to the theory that the hen contributes more significantly than the cock due to mitochondrial DNA (e.g. there is evidence of paternal contribution and the majority of mitochondrial processes are coded for by nuclear DNA). In the absence of data to support this claim, you should avoid placing any disproportionate value on the dam.
  - Due to cross over during meiosis, grandparents DO NOT equally contribute 25%).

Simple Genetics

- Each trait is coded for by one or more pairs of genes.
- A given gene resides on a specific location of a specific chromosome. This location is known as a locus (the plural form is loci.)
- While an individual will have exactly two genes for each locus (one coming from each parent), there are multiple versions of that gene within the gene pool (the breeding population). Each different version is known as an allele.

Simple Genetics

- For example, the trait “feather color pattern” has at least four alleles (Dark Check, Check, Bar and Barless) for which a given bird will have at most two.
- All four of these phenotypes are coded for by a single pair of genes on one of the chromosome pairs. If the parents both contributed the “Bar” gene (+) the resulting pigeon will have a Bar color pattern. However, if both parents contributed the “Check” gene, the resulting pigeon will have a Check color pattern.
- When genes for a given pair are of the same type (allele) the pair is said to be homozygous. If the pair consists of two different alleles the pair is said to be heterozygous.

Simple Genetics

- When heterozygous, there are two possible ways the trait might be expressed (though it will always be expressed the same way for a particular gene pair).
  - Complete dominance is when one allele determines the phenotype (dominant) and the other allele is completely masked (recessive) as if it didn't even exist. What we see is the phenotype and what is actually there in the genes of the cells is known as the genotype.
  - Incomplete dominance is when the gene expression is intermediate in the heterozygous state (the gene locus for Grizzle is one example).

Simple Genetics

- Lets look at our example of feather color pattern. There are four possible alleles.

Allele Symbol		Expression
C^T	(known as the T-pattern check)	Dark Check
C	(Uppercase)	Check
+		Bar
c	(lowercase)	Barless

- C^T > C > + > c or in other words -
  - Dark Check is dominant over Check, Bar and Barless
  - Check is dominant over Bar and Barless
  - Bar is dominant over Barless

Simple Genetics

These are all the possible ways the alleles can be paired up.

Genotype	Phenotype
$C^T\ C^T$	Dark Check
$C^T\ C$	Dark Check
$C^T\ +$	Dark Check
$C^T\ \underline{c}$	Dark Check
$C\ C$	Check
$C\ +$	Check
$C\ \underline{c}$	Check
$+\ +$	Bar
$+\ \underline{c}$	Bar
$\underline{c}\ \underline{c}$	Barless

Simple Genetics

- This is why you can't get a Check or a Dark Check when you mate two Bars together. If you see such a situation in a pedigree you might suspect there is a mistake somewhere (be careful though because people will sometimes call a light Check a Bar).

Sire / Dam	+	+
+	+ +	+ +
+	+ +	+ +

Example of a Bar cock with the ++ genotype mated to a Bar hen also with the ++ genotype. The mating will produce 100% Bars.

Simple Genetics

- But you can get Bars from the mating of two Checks.

Dam \ Sire	C	+
C	C C	C +
+	+ C	+ +

Example of a Check cock with the C+ genotype mated to a Check hen also with the C+ genotype. The mating should produce 75% Checks and 25% Bars.

Simple Genetics

- Though some Checks when mated will not ever produce a single Barred offspring.

Dam \ Sire	C	C
C	C C	C C
C	C C	C C

Example of a Check cock with the CC genotype mated to a Check hen also with the CC genotype. The mating will produce 100% Checks.

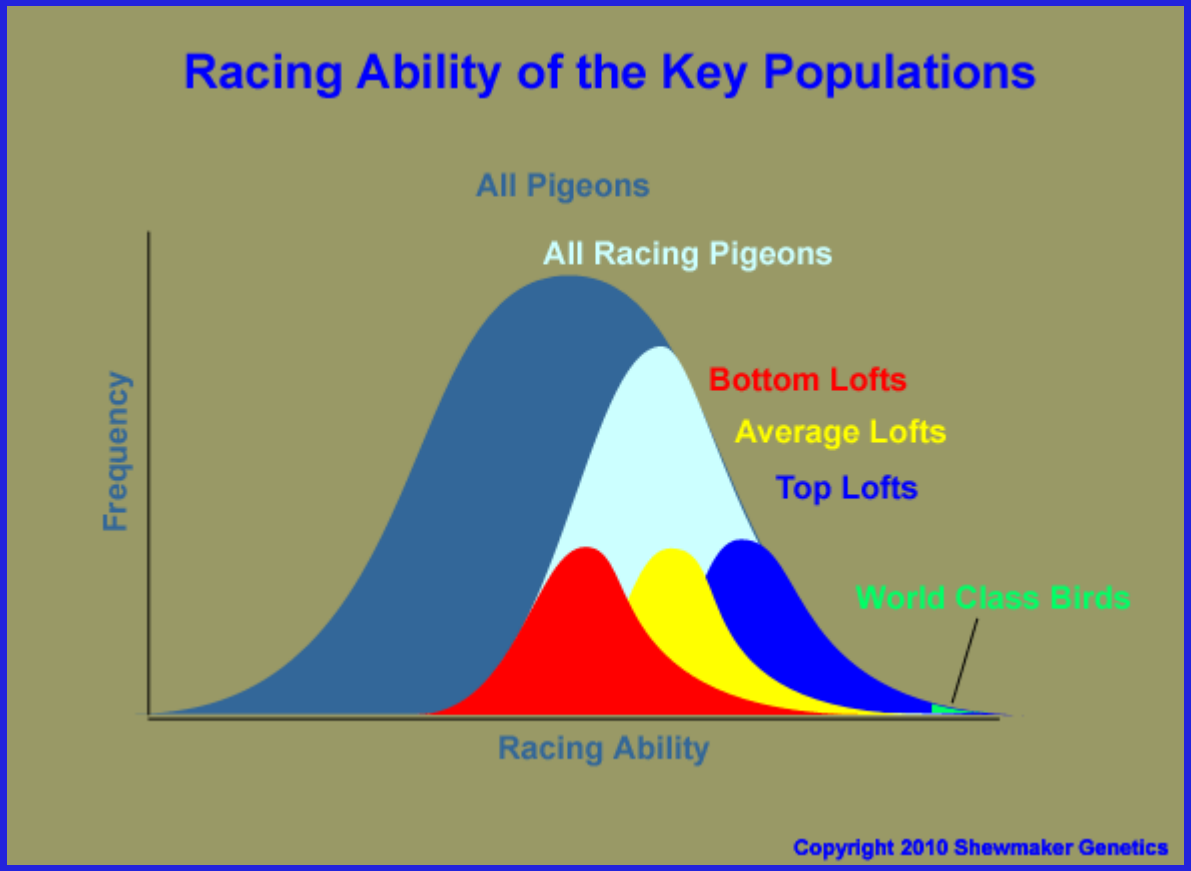
Our Concern Is With The Big Picture

- Genetics though is much more complicated than what we have explained so far for a simple pair of genes.
- This leads many people to get lost in the minutia of DNA, genes, mutations and such.
- It is much more important to understand the big picture. It is fine to understand how a watch works, but most people are better served by simply knowing how to tell time.
- In general, don't think in terms of individual genes, individual chromosomes or even individual birds. Everything should be approached from the point of view of the *population* of racing pigeons – specifically those in your loft and those in the rest of the sport.

The Bell Curve

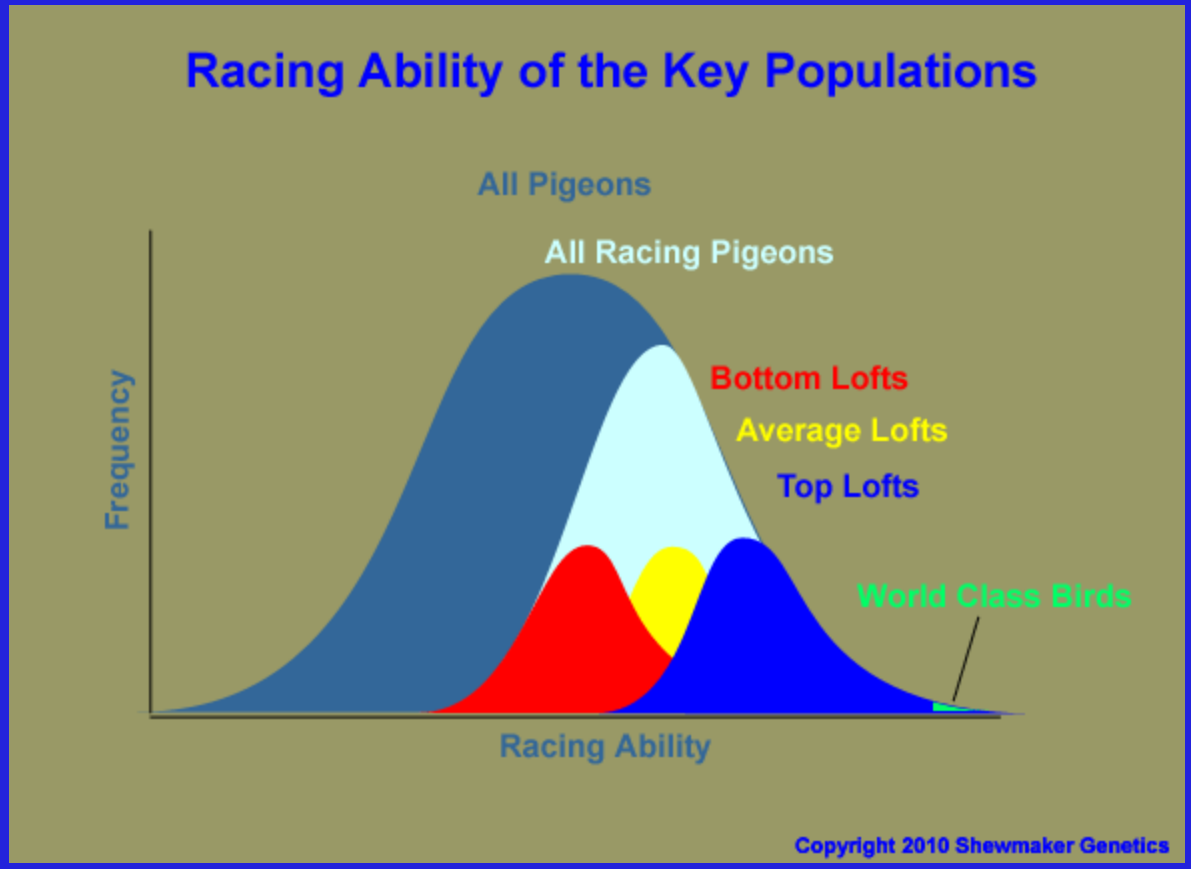
- For many traits, genetic expression is actually determined not by the action of a single pair of genes but multiple pairs – two, three, dozens and perhaps even hundreds in the case of those non-discrete traits like “height” or “body weight” or in our case “racing ability”.
- If you do the math and graph outcomes of various matings using many genes, instead of a box where 75% are Checks and 25% are Blues (as on Slide 20), we get a distribution that is known as a bell curve.
- The next five slides are the most important of the whole seminar.

The Bell Curve



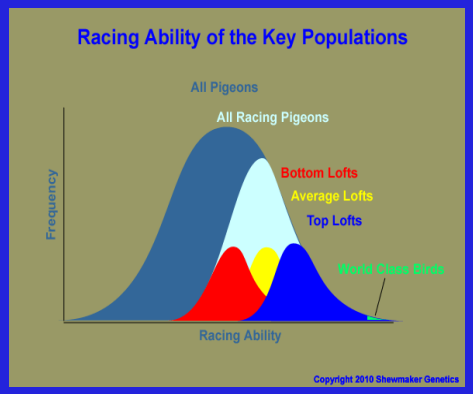
- Notice that the “Bottom Lofts” and most of the “Average Lofts” may not even have the necessary genes in their pool to breed world class birds.

The Bell Curve



- But also notice that in the “Top Lofts”, few of the birds are “World Class” and many are on a par with the “Low” and “Average” lofts.

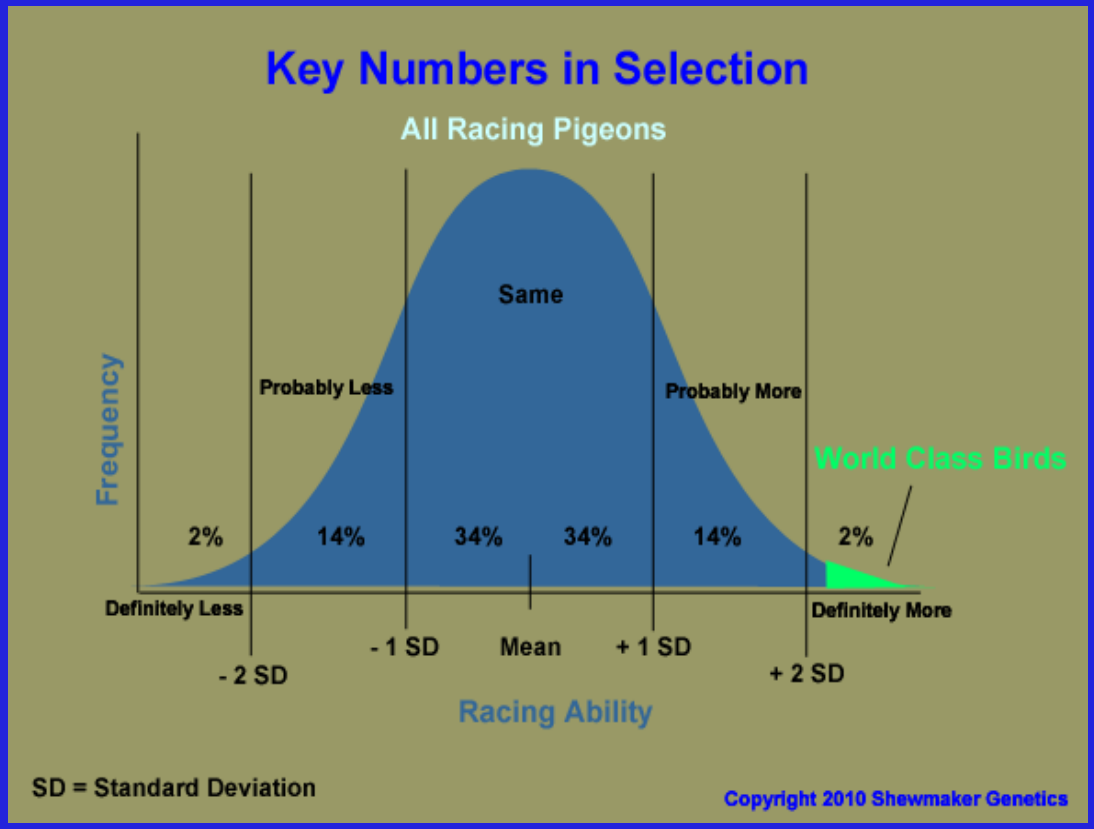
The Bell Curve



- Here is the hard cold fact – most of our pigeons are not genetically up to our assumptions and expectations.
- ***IF*** you have a "Top Loft" complete with a few "World Class" pigeons, you ***MIGHT*** produce **1 in 10** birds which should be kept to breed the next generation.
- If you are in the "Average Loft" category it is probably closer to 1 in 100 and in the "Bottom Lofts" it is closer to 1 in 1000 or maybe even 1 in 10,000.

The Bell Curve

- If you aren't selecting at least the top 16% *you probably aren't selecting at all*.



- If you really want to make progress you need to be selecting at least the top 2%.

The Progress Equation

- Your ability to make genetic progress and the speed at which you make this progress is **absolutely** related to these three factors (*memorize this slide*!):
  - The **accuracy** of your selection
    - *So if you think toe color is related to superior racing and this is what you select for, you are probably not really doing any selection at all with respect to racing ability. In my view the most accurate selection criteria (by a wide wide margin) are race results to the same loft. Nothing else comes close.*
  - The **intensity** of your selection
    - *Selecting from the top 16% is far less intense than selection from the top 2% which in turn is far less intense than selecting from the top 1%*
  - The **time** interval over which you do the selection
    - *One season is not enough, but two or three will surprise you. Changing to a new fad (or a new family) every few years will doom any real progress.*

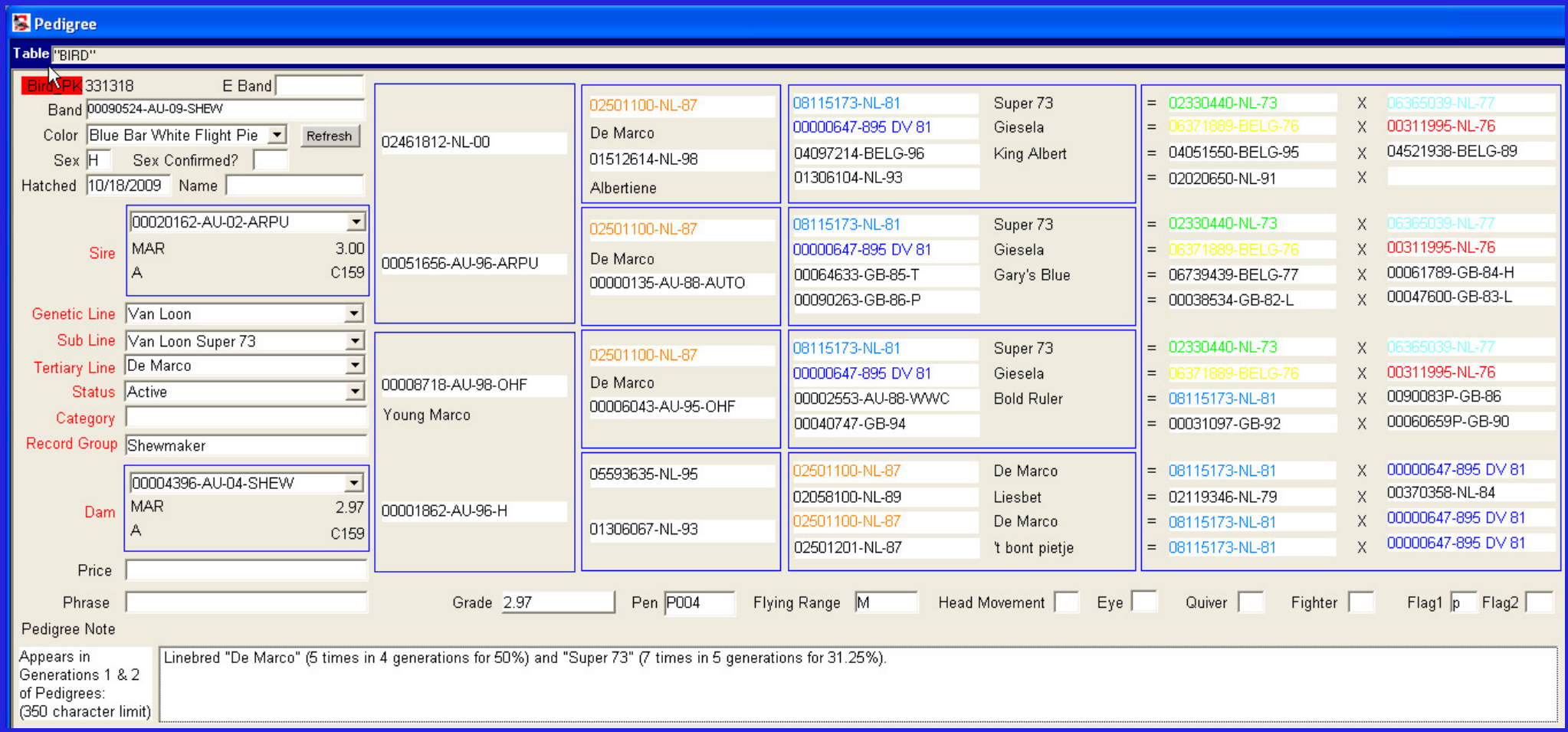
A Road Map for Genetic Improvement

1. Assemble an appropriate gene pool. Don't assume though that you have to go buy new birds. While we all probably need to cull out most of what we have, the American Racing Pigeon Gene Pool is very deep and until you conduct a fair test you really can't say you don't already have the right genes.
2. Roll, roll, roll the dice!!!
    - If the genes are in the pool, your job is to assemble them all in one bird.
        - Breed, test and cull until you get it. Then do it again to get another one.
        - Change the matings and do it again.
        - Use linebreeding to try to concentrate the genes of elite birds.

A Road Map for Genetic Improvement

2. Roll, roll, roll the dice!!! (continued)

- Here is a good example of linebreeding (DeMarco and Super 73):



A Road Map for Genetic Improvement

2. Roll, roll, roll the dice!!! (continued)

- Another good example of linebreeding (Super 73):

Strategic Loft (DSN: SGC/11/PGN_PRD; DB Info: Dev & Prd PGN)

File Edit Rows Forms Reports Processing Current Sheet Tools Window Help

Ancestors By Percentage

Table "LINEBREEDING PC"

This bird has	this ancestor who appears			this many times	in this # of generations	with this genetic percentage.
00004647-AU-14-SHEW	00050444-AU-05-ARPU		VAN	1	1	50.0000
00004647-AU-14-SHEW	00070267-AU-07-SHEW		V.N	1	1	50.0000
00004647-AU-14-SHEW	08115173-NL-81	Super 73		24	9	31.4453
00004647-AU-14-SHEW	02436201-NL-01	Super Marco	VAN	1	2	25.0000
00004647-AU-14-SHEW	00000016-AU-97-GSF	Sweet 16	VAN	1	2	25.0000
00004647-AU-14-SHEW	00005953-AU-95-OHF	Java - He's Hot!	VAN	1	2	25.0000
00004647-AU-14-SHEW	00003395-AU-03-SHEW		VAN	1	2	25.0000
00004647-AU-14-SHEW	02501100-NL-87	De Marco	VAN	8	8	24.2188
00004647-AU-14-SHEW	02330440-NL-73	De Olieman	JV	20	9	16.7969
00004647-AU-14-SHEW	06365039-NL-77	Crackske		18	9	15.2344
00004647-AU-14-SHEW	00002778-AU-88-WWC	Super 2778	VAN	3	8	13.6719
00004647-AU-14-SHEW	00000647-895 DV 81	Giesela	VAN	9	9	12.8906
00004647-AU-14-SHEW	02591102-NL-98	Evita	VAN	1	3	12.5000
00004647-AU-14-SHEW	00001084-AU-96-GSF		VAN	1	3	12.5000
00004647-AU-14-SHEW	00004484-AU-96-FRC		VAN	1	3	12.5000
00004647-AU-14-SHEW	00000132-AU-88-AUTO		VAN	1	3	12.5000
00004647-AU-14-SHEW	00008303-AU-98-SHEW	Gold Mine	VAN	1	3	12.5000
00004647-AU-14-SHEW	00020163-AU-02-ARPU	Top Marco	VAN	1	3	12.5000

A Road Map for Genetic Improvement

3. For selection purposes, use only contemporary group test results (Contemporary Groups are groups of birds where the environmental factors for every member of the group are as equal as possible).
    - Loft results for YB and OB races (Combine wins are great for bragging rights and marketing, but useless for genetic selection)
    - Training tosses
    - One Loft Races
    - Your own Contemporary Group Tests

A Road Map for Genetic Improvement

4.Perform tough but fair tests. The ideal test is one where only one bird comes in first and is followed over a reasonable period of time with small drops, culminating in all (or at least most) of the birds coming home on the day.

- The worst possible test is a smash where no one comes home.
- The second worst test is where the vast majority of the birds come home in the first drop. (It would be an excellent result for YB or OB race or even a training toss but not for a test. A drop of 16 birds for example that score 1-16 in the club or combine speak highly of the handler, but it is really difficult to known whether you had 1 leader and 15 followers or even if you had a flock of 16 and no one bird capable of doing the same on their own.)

A Road Map for Genetic Improvement

5. Form your conclusions on patterns, not individual results. In general, don't treat anything as significant until you have three or more noteworthy results.
   - Don't get attached to the pretty ones or the expensive ones or even the ones with a single win. If the results aren't repeatable, they probably aren't statistically significant from a genetic perspective.
   - Two noteworthy results and you may have something.
   - Three noteworthy results and you probably do.
   - Multiple noteworthy results among relatives is the gold standard!

A Road Map for Genetic Improvement

6. Shoot for 2% and 1% if possible

- Of course, not every bird you stock will be in the top 2%. There are many reasons for exceptions, just don't make these exceptions without well thought out and solid reasons.
- The message here is not to make it seem impossible, but to emphasize that most of the pigeons we produce and keep are not suitable for moving the flock forward, so be (much) more selective.

A Road Map for Genetic Improvement

7. When you get one of the 1% birds, know it is special and do everything you can to breed (and test) as many of its youngsters as you can.
    - For 1% cocks:
        - Polygamous breeding
        - Artificial Insemination – 300 youngsters a year possible from a single cock
    - For 1% hens:
        - Foster off the eggs to pumper pairs
        - Breed to multiple cocks
    - Repeat the mating and variations of the mating using relatives

A Road Map for Genetic Improvement

8. Artificial Insemination is an incredibly powerful tool for the proliferation of the elite birds.
    - Fresh semen can typically be collected three times a week, year round.
        - One collection can typically inseminate six to ten hens when used fresh and about three when frozen.
        - Once frozen the semen can be stored indefinitely (literally for decades).

A Road Map for Genetic Improvement

8. Artificial Insemination Advantages (continued).

- Semen can be collected and frozen from race team cocks during and between race seasons. This is huge.
  - It allows us to preserve the genetics of the elite birds while continuing to race them and gather data. In the past we have often had to chose between stocking and racing which resulted in some birds being either
    - stocked too early before their true racing value was accurately established, or
    - sent to one too many races wherein a valuable bird was lost.

LDHA – The Future is Now

Recent research has shown that the LDHA gene may play a very important role in racing performance of pigeons.

I believe this is a very important topic, but a strong word of caution is in order.

- First and foremost, the LDHA gene is but one of many that contribute to racing ability. Anyone who jumps off the cliff at this point and assumes that LDHA is the secret and exclusive “silver bullet” which will ensure immediate racing success, is almost certainly wrong and will likely end up being very disappointed.
- By the same token, anyone who dismisses these research results as techno babble and irrelevant to real world racing is also very likely wrong and might be missing a significant opportunity to move their gene pool dramatically forward.

LDHA – The Future is Now

What is it?

- LDH stands for **Lactate Dehydrogenase**, a group of enzymes that are involved in the conversion of lactate to pyruvate (and vise versa).
- LDH is found in the cells of virtually every living organism (plants, animals and even single cell organisms known as prokaryotes).
- In mammals and birds, there are three different forms of this enzyme that are largely found in specific cell types, reflecting the different functional requirements of those cells. Each type is coded for by a different gene.
- The type **A form** of LDH is found largely in muscle cells and is coded for by the **LDHA gene**

LDHA – The Future is Now

What is it?

- When sufficient oxygen is present, muscle cells produce energy from a metabolic process known as aerobic respiration.
- When the exercise is sufficiently intense or prolonged such that there is an **oxygen deficit**, muscle cells use an alternative anaerobic process that **produces lactate**.
- For many years, it was erroneously thought that muscle fatigue during strenuous exercise was due to a build up of lactic acid. We now know that there are several factors that contribute to fatigue, but **how a cell utilizes and/or regulates lactate levels can influence race performance**.

LDHA – The Future is Now

What did the research find?

- In 2002, two different alleles were found in pigeons for the LDHA gene, A and B. This means the possible genotypes for LDHA in pigeons are BB, AB and AA.
- In 2006, DNA testing was used to determine the frequencies of the A and the B alleles in four groups of pigeons:
  - The group of fancy pigeons (non racing breeds) had an A allele frequency of **0.6%**.
  - A control group of race pigeons (not screened for racing results) had an A allele frequency of **6.5%**.
  - A group of race pigeons from throughout Poland (specifically screened for "top" racing results) had an A allele frequency of **20.3%**.
  - A group of race pigeons from throughout China and Taiwan (specifically screened for "top" racing results) had an A allele frequency of **21.9%**.

LDHA – The Future is Now

What did the research find?

- In 2014, another study was done which again demonstrated a correlation between the frequency of the A allele and race performance.
- This 2014 study also raised the possibility that the influence of the AA genotype may exceed that of the AB genotype in races under 250 miles and that the A allele may be less important in the distance races of more than 311 miles.
- At this point there are many unanswered questions. Much additional research needs to be done.

LDHA – The Future is Now

What does this all mean?

- In selecting for race performance, pigeon breeders have indirectly been selecting for the A allele of the LDHA gene (along with others of course that have not yet been identified). This is shown by the ten fold increase in the frequency of the A allele between fancy pigeons and the control group in the 2006 study.
- Today, the LDHA genotype of any pigeon can be determined by a DNA test. In the US, the test can be performed for $20 with the submission of a single secondary feather. (www.genecheck.com)
- Another good lab is www.animalgenetics.us

LDHA – The Future is Now

What does this all mean?

- It is now possible for the astute breeder to “fix” the A allele of the LDHA gene in their breeding flock, making its frequency 100%. They are then free to focus on additional improvement through the selection of other key genes, knowing the A allele will always be there in any birds they produce.
- Additional gene loci are being studied and we can expect more DNA tests to be available in the not too distant future.

LDHA – The Future is Now

Don't forget – this is an important gene, but it is not the whole story. There are many outstanding birds (both racers and breeders) who are BB.

- Don't make the mistake of culling birds just because they do not carry the A allele.
- Think instead in terms of adding the A allele to improve existing gene pools and then increasing its frequency.

LDHA – The Future is Now

There are several distinct traits which contribute to a bird who wins races. All of these traits are strongly influenced by the environment, but they also have a significant genetic component. The bird has to have the:

- **ability to orient** itself quickly at the time of release AND maintain the proper orientation on the flight home.
- **ability to fly** at a speed and for a duration that is competitive with the rest of the birds in the race. Many sprint birds, for example, just do not have the tools for competing in a long distance race.
  - Note: LDHA would be only part of the story for this trait and would influence only this one trait of the six listed. Clearly you should not make LDHA the only focus of your breeding program.
- **desire to want to get home quickly** (as opposed to just plodding along until it gets there).
- **intelligence to resolve challenges** that inevitably arise at some point during at least some races (*i.e.* strong winds or a storm that breaks up the flock and blows them off course).
- **ability to learn** from their experiences and their mistakes.
- **mindset of a leader** (which is somewhat at odds with their normal gregarious nature).

Closing Thoughts

- Remember genes determine the potential. Environment limits how much of that potential is realized. As people get better and better at perfecting the environmental factors (condition, training, fuel, motivation, health and luck) genetics is the one remaining **but unlimited** area in which improvement can still be made.
- Figure out what ***you*** are trying to accomplish.
- Remember it is a hobby and it is ***your*** hobby. Do it your way.
- Keep it fun.